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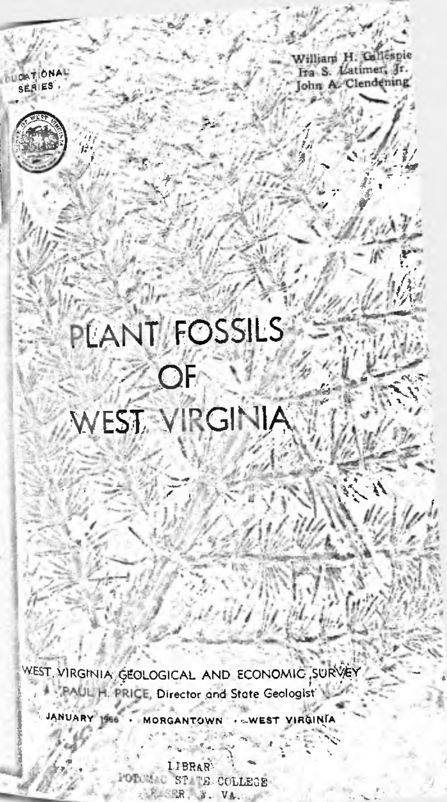

PLANT FOSSILS OF WEST VIRGINIA

WEST VIRGINIA GEOLOGICAL AND ECONOMIC SURVEY
PAUL H. PRICE, Director and State Geologist

JANUARY 1966 · MORGANTOWN · WEST VIRGINIA

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LETTER OF TRANSMITTAL

Honorable Hulett C. Smith
Governor of West Virginia, and
President, Geological and Economic Survey Commission
Charleston, West Virginia

Dear Sir:

This publication on fossil plants, an addition to our Educational Series, is the revised edition of a popular earlier (1960) report that was in such demand that all supplies were exhausted shortly after its printing. Interest in West Virginia fossils remains high, so it was necessary for us to expand and update the material to meet the many requests for this information.

Plant Fossils of West Virginia was written by William H. Gillespie, of West Virginia University, and Ira S. Latimer, Jr., Coal Geologist, and John A. Clendening, Palynologist, both members of our staff.

We hope, in the not-too-distant future, to complete companion volume to this report covering the animal fossils our State.

Resp [illegible] ubmitted,

Paul [illegible] Director
and [illegible] ogist and
Pr [illegible] ology

Morgantown, West Virginia
January 1, 1966

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AUTHORS' PREFACE

In 1960, the West Virginia Geological and Economic Survey published **A Guide to the Common Fossil Plants of West Virginia.** We prepared this booklet to fill the need of the many persons who are interested in the fossils of the State, both the serious student and the casual collector. Response to the publication was overwhelming, and the entire printing was distributed within three years.

This new booklet, **Plant Fossils of West Virginia**, is an updated and expanded version of the earlier work. Much of the material is the same, but new sections have been added on the geologic sequence of plant life in the State and the importance of spores and pollen. To make the work more complete, descriptions and illustrations of Devonian, Mississippian, and Recent floras have been included. We are hopeful these additions will make the publication more useful and interesting.

The new drawings in this publication were prepared by Paul W. Queen, Draftsman with the Geological Survey. We thank him for his fine and careful work.

William H. Gillespie
Ira S. Latimer, Jr.
John A. Clendening

Morgantown, W. Va.
January 1, 1966

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PLANT FOSSILS OF WEST VIRGINIA

INTRODUCTION

There are many ways of enjoying the beauties of nature. One is the simple delight that comes from seeing a wooded hillside, a mist-shrouded waterfall, a snow-capped mountain, a moss-covered boulder—all of which have direct appeal to the eye and provide a distinct sense of pleasure. Another is the intellectual appeal which comes as a result of understanding the forces of nature that have provided these wonders of the landscape.

Although we live on the earth, it is surprising how very little most of us know about it. We accept without question the mountains, the valleys, the streams, and the rocks that are so intimately bound up in each—simply because they are so familiar. As an example, consider a lump of coal. Some see only a black rock, others see large industrial furnaces, and still others see only the tired husbands and fathers as they wend their way home from the pits. Perhaps a few, however, in their mind's eye, fade back through countless ages to the time when coal was being formed. To do so is to visualize West Virginia as a swampy plain, devoid of mountains, but dotted with clumps of gigantic plants, which, as successive generations matured and fell, slowly accumulated into the extensive masses of vegetable debris from which our coals were formed.

The subject of this booklet is the plants from the ancient past and their preservation in the earth's crust. The fascination and thrill of breaking open a rock and finding the remains of a plant which has been extinct for millions of years is a rewarding experience. Who knows, the next blow may disclose a plant never before known to man, or one which will aid in further deciphering the earth's history. This anticipation of finding something unknown can be shared by everyone. In recent years, many high school biology classes have conducted annual "fossil hunts", and mining and industrial fairs have offered lucrative prizes for the best fossil exhibits. This interest is undoubtedly extended by the fact that the humblest collector has just as good a chance of finding a unique specimen as does the most learned scholar. It is hoped that this publication will serve as a basis for studying and understanding the ancient plant life of West Virginia.

The acceptance accorded the first edition, **A Guide to the Common Fossil Plants of West Virginia**, has made it possible to revise and expand the material into the present form. The authors wish to express their appreciation again to Dr. Paul H. Price, Director and State Geologist of the West Virginia Geological and Economic Survey, for his continuing interest in paleobotanical studies.

HISTORY

Paleobotanical observations have been intermittently recorded in West Virginia since early in the nineteenth century.[1] The earliest publication dealing with fossil plants of this State is apparently the 1836 paper by Hildreth and Morton,[2] which contained remarks and illustrations pertaining to fossil leaves and stems found in the Monongahela and Kanawha River valleys. In the 1850's Leo Lesquereux, widely acknowledged as the "Father of American Paleobotany", described some of the fossils mentioned in this initial paper as new to science and published new names for them.

Several internationally-known geologists and paleobotanists have published observations on fossil plants from West Virginia. This list includes such names as Israel C. White, William M. Fontaine, David White, Frank H. Knowlton, David B. Reger, W. J. Jongmans, Hans Bode, Richard Krausel, and nearly all of the contemporary American paleobotanists.

During the earlier years, deep-mining operations provided a majority of the specimens, but the advent of mechanical mines, which treat coal and shale as one unit, of preparation plants which pulverize the plant-bearing shales, and of tipples serving two or three coal beds at the same time, has nearly eliminated this source of supply. The expansion of surface-mining activities has facilitated collecting, but immediate attention is often needed to prevent the fossils being reburied by back-filling or damaged by weathering processes.

Large gaps still exist in our paleobotanical knowledge of West Virginia. During the past few years a new beginning has been made, and although it will be years before a comprehensive picture is available, we are now on our way to a fuller understanding of our ancient plants.

KINDS OF FOSSILIZATION

The word fossil has been in common use for about 400 years. It was originally applied to almost anything that was found buried in the earth. In recent years, however, the term has been restricted to the remains or traces of organisms at least as old as the "ice ages", thus excluding the buried remains of our recent life. For example, the fragments of pottery, tools, or skeletons excavated by archeologists are not regarded as fossils.

Fossils, although often abundant locally, represent only a small fraction of the total number of plants that have existed on the earth. As the plants died, their remains were subjected to decay and other destructive forces. Only a small percentage survived this initial alteration, and of these only a small proportion could possibly become fossilized because most of them did not live in areas of active deposition of sediment. Only a few of those actually buried survived subsequent erosion and, of the ones that did, only a small fraction are exposed at the surface where they have a chance of being found and studied. This small fraction forms the basis for our knowledge of ancient plants—the study of which is termed **Paleobotany**.

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[1] For more complete information see the articles listed in the supplemental reading list on page 40.

[2] American Journal Science, 29:1-154.

Plants and plant fragments have been preserved in various ways. The most common method was by burial in seas or swamps on muddy floors which later became rock. In some parts of the world volcanic ash covered ancient forests. In others, plant fragments were preserved in calcareous nodules and in pieces of amber (fossilized resin).

For all practical purposes, plant fossils can be grouped into three main categories: (1) compressions and impressions, (2) petrifactions, and (3) casts and molds.

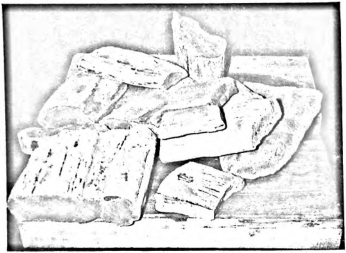
Compressions and Impressions

This form of preservation is the most common in West Virginia. Here the plant fragments, such as leaves or twigs, fell into the water, became water-logged, and sank to the bottom of the swamp or sea where they were covered with clay, silt, or other fine sediments. The gradually increasing weight pressed out the water and air until finally only a thin film of carbonaceous material remained. At the same time, the surrounding sediment was being consolidated into rock, usually shale or fine-grained sandstone. Upon splitting such rocks today, we find that one side contains a nearly intact "compression" of the plant fragment while the other shows an impressed counterpart or "impression". These are the "positive" and "negative" sides, respectively.

Another type, which we shall term "replacement", occurs when the plant material is totally replaced by a mineral. The resulting film (Plate 38, fig. 1) normally retains all of the external features of the plant fragment and thus is subject to identification.

The outer layer of the spores of ancient plants was composed of a very resistant material—so resistant, in fact, that these plant bodies were preserved by the millions. These minute compressions are microscopic, but quite often the residue left after rocks such as coal or shale are chemically dissolved will be composed of hundreds of these tiny links to the past (See page 39). A scientist who has specialized in the study of spores and pollen is called a **Palynologist** and his profession is referred to as **Palynology**. Increasing use is being made of palynology in the field of applied geology where it serves as another tool in unraveling the environments of the past. Spores and pollen may also serve as stratigraphic markers.

FIGURE 1.—Petrified logs from roof shales of Washington coal of Dunkard Age.



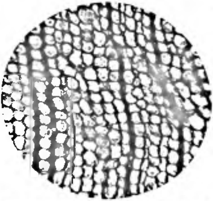


FIGURE 2.—Greatly magnified section from a petrified log (Kanawha County) showing that cell structure is often well preserved.

Casts and Molds

A mold was formed when a plant organ, usually some bulky part such as a root, seed, or stem, was buried in loose sand or mud. As the specimen was buried deeper and deeper, percolating water dissolved the chemical constituents and carried them away. If, by chance, the walls of the resulting cavity were strong enough to resist crumbling, an exact mold of the outside of the object resulted. Sometimes the percolating waters filled the mold with other mineral matter which hardened and formed a cast of the original specimen (Plate 4). When a natural mold is found, it can be filled with plaster-of-paris or self-vulcanizing liquid rubber to form a cast of the original.

Petrifactions

Petrified plants are the rarest and, botanically, the most important of the three types of preservation because it is only in petrifactions that internal cell structure can be studied. As the petrifying process began, the plants were apparently immersed in water containing minerals in solution. Gradually the dissolved mineral matter separated out of solution and was deposited as a solid filling in the cells. Sometimes the material was silica; at other times it would be an iron compound such as pyrite; or magnesium, or calcium carbonate, to name the more common materials (Figs. 1 and 2).

Coal-balls occur as hard concretionary masses in the roof of coal beds and are composed of masses of plant debris impregnated with and surrounded by calcium or magnesium carbonate or pyrite. Although they are the best source of petrified materials, they have not been found in West Virginia.

Pseudofossils or Artifacts

Inorganic objects that resemble fossil plants are called **pseudofossils** or **artifacts**. Mineral matter often crystallizes in fern-like patterns along cracks or bedding planes in shales (Plate 1, fig. 2) and small rounded stones sometimes bear a superficial resemblance to large seeds, potatoes, oranges, etc. Professional geologists also are sometimes temporarily deceived as was shown several years ago when some large oval sandstone objects (Plate 2) in upper Devonian rocks near Elkins, West Virginia, were mistakenly described as tree trunks.

WHERE TO FIND FOSSILS

A common question is, where do you find plant fossils? There is, of course, no really definite answer, but in this State they are most likely to be found in rocks associated with coal. This does not mean that they are found nowhere else, as the paragraphs on the sequence of plant life in West Virginia show (p. 16), but they are usually more abundant, better preserved, and easier to collect around active coal mines. Experience helps, but a beginner will meet with more certain success if he searches in the shaly rocks that occur just above coal beds (Fig. 6 or in the "partings" or shale layers that often separate the coal into distinct benches. It is easier and usually more productive to examine the refuse rock piled in "dumps" near underground mines or pushed to one side in surface or strip mines (Fig. 6) than it is to excavate natural outcrops. It is futile to attempt to collect fossil plants on burning "dumps" or "gob piles" as the carbonaceous film disappears very quickly in such situations.

Almost any place you may wish to collect will be on private land, therefore, one of the first duties is to obtain permission from the owner before entering the property. This is important as a matter of courtesy and also as a matter of safety because explosives and machinery often constitute hazards in active quarries and strip mines. **As a final word of caution, an inexperienced person should never enter an abandoned drift mine nor should he walk too close to the wall of a strip mine—regardless of permission—since rocks tend to break up during weathering and often fall without warning.**

HOW TO COLLECT, PROCESS, AND STUDY FOSSIL PLANTS

A collecting trip is only as good as the advance preparation. Essential equipment includes: (1) a rock hammer,

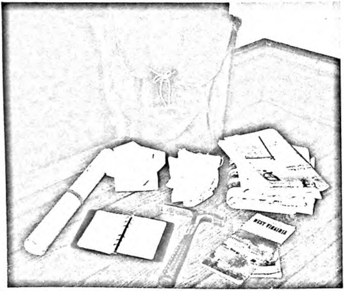


FIGURE 3.—Common equipment used in collecting.

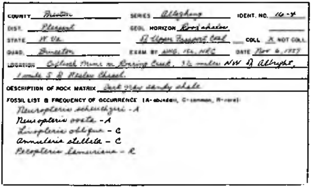
(2) road map, (3) topographic map, (4) knapsack, box, or pack basket, (5) newspapers and soft tissue, (6) note book, (7) paper sacks, (8) chisels, (9) magnifying lens, and (10) a pick and shovel.

The most important implement is a geologist's hammer, preferably like the one shown in Figure 3 which has a flat face on one end and a dull cutting edge on the other. The thin edge will prove especially helpful in splitting layered rocks. As might be imagined, the pick or mattock and shovel are used in digging out the larger rocks for splitting.

Both a State highway map and the appropriate topographic quadrangle are important accessories for recording the exact location from which the fossils are collected. This information is vital in determining the age of the rocks.

A good collection includes as complete a set of fossils as it is possible to obtain. For this reason, every recognizable fragment is laid aside as it is found. The accumulated specimens are then examined and the better examples of each type are selected for more intensive study. A 5- to 10-power lens or magnifying glass is indispensable in this operation. The relative abundance of each kind of plant, along with other notes pertinent to the collection, should be recorded in the notebook or on specially prepared forms before leaving the site .The form in Figure 4 provides a quick and handy way to record the necessary data.

The selected specimens must be wrapped before they are transported home. Those that are carried loose will certainly be scratched or broken and their value impaired. The delicate specimens are usually wrapped in tissue paper and placed in small boxes, while the larger, bulkier ones are wrapped in newspaper. The date, locality, and names of the collectors are written upon a small card or piece of paper and included in



COUNTY Preston SERIES Allegheny IDENT. NO. 16-4
DIST. Pleasant GEOL. HORIZON Roof shales
STATE W. Va. of Upper Freeport Coal COLL. X NOT COLL.
QUAD. Bruceton EXAM BY AMG, [illegible], NRC DATE Nov 6, 1957
LOCATION Outcrop [illegible] on Roaring Creek, 1½ miles NW of Albright, 1 mile S of Healey Chapel.
DESCRIPTION OF ROCK MATRIX Dark gray sandy shale
FOSSIL LIST & FREQUENCY OF OCCURRENCE (A-abundant, C-common, R-rare)
Neuropteris scheuchzeri - A
Neuropteris ovata - A
Linopteris obliqua - C
Annularia stellata - C
Pecopteris lamuriana - R

FIGURE 4.—Collection record card.

ERA	SYSTEM	GROUPS AND FORMATIONS		IMPORTANT COAL BEDS
PALEOZOIC (UPPER)	TRANSITIONAL PERMIAN-PENNSYLVANIAN?	DUNKARD GROUP	GREENE FORMATION	NONE PRESENTLY OF VALUE
			WASHINGTON FORMATION	WASHINGTON◂
	PENNSYLVANIAN	MONONGAHELA GROUP		WAYNESBURG◂ SEWICKLEY REDSTONE PITTSBURGH◂
		CONEMAUGH GROUP		ELK LICK BAKERSTOWN◂ MAHONING
		ALLEGHENY GROUP		UPPER FREEPORT◂ LOWER FREEPORT UPPER KITTANNING◂ MIDDLE KITTANNING◂ NO. 5 BLOCK◂ CLARION
		POTTSVILLE GROUP	KANAWHA FORMATION	UPPER MERCER STOCKTON◂ COALBURG BUFFALO CREEK WINIFREDE CHILTON THACKER HERNSHAW WILLIAMSON CEDAR GROVE◂ LOWER CEDAR GROVE ALMA PEERLESS } CAMPBELL CREEK◂ NO. 2 GAS } POWELLTON EAGLE LITTLE EAGLE LOWER WAR EAGLE GILBERT DOUGLAS
			NEW RIVER FORMATION	IAEGER SEWELL "B" SEWELL◂ WELCH LITTLE RALEIGH BECKLEY◂ FIRE CREEK NO. 9 POCAHONTAS
			POCAHONTAS FORMATION	NO. 7 POCAHONTAS NO. 6 POCAHONTAS NO. 5 POCAHONTAS NO. 4 POCAHONTAS◂ NO. 3 POCAHONTAS◂ NO. 2 POCAHONTAS

FIGURE 5.—Geologic position of the important coal seams of West Virginia. The best plant fossil collecting horizons are indicated.

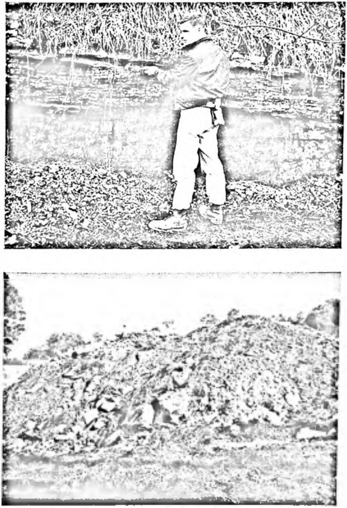


FIGURE 6.—Two excellent places to collect fossil plants: top, shales above outcropping coal seams; bottom, blocks of shale in a strip mine.

each package. Some collectors prefer to write this information on each piece of paper. Although time-consuming, this record assumes importance if more than one location is visited on the same day or if, for some reason, the materials can not be labeled at once. It is advisable to wrap from the corner of the paper, much as a grocer wraps meat, to prevent unfolding while in transit. It is preferable to pack the wrapped specimens in rows on edge, instead of flat, as additional insurance against breakage.

A small, square-faced hammer and a series of small chisels should be available for trimming off superfluous material and for excavating partially exposed specimens. Broken specimens can sometimes be glued together with all-purpose cement or clear airplane dope.

As each rock is unwrapped, it should be cleaned and permanently numbered. Perhaps the easiest and clearest way is to paint a small square with colored Butyrate (model airplane) dope. A coded number is added with India ink or other indelible material (Fig. 7). Specially designed marking pens are available for writing on rocks, and carborundum-pointed pencils can be used to scratch the numbers directly onto the rock surface.

All specimens should have a collection number and an individual specimen number. The collection number is recorded in a record book along with the field data relating to it,

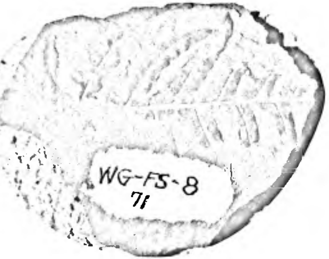


FIGURE 7.—A properly labeled specimen.

such as the exact locality, collectors, date collected, probable age (exact if known) and so on. This permanent record book is absolutely essential. If reliance is placed on memory, or on loose paper labels, the information is apt to get mixed or misplaced and the scientific value of the specimens impaired or entirely lost.

Amateurs sometimes paint fossils with varnish or plastic, but this seldom enhances the specimen. It has the further disadvantage in that it often ruins the fossil for critical study and usually renders it unfit for photographing. Note the pinnule in Plate 13, fig. 6, that has been coated with clear fingernail polish.

After being cleaned and labeled, the collection is ready for study. It is at this point that one often finds some of the material is almost impossible to identify. The available reference books and scientific papers are seemingly of little help. In such cases, the only solution may be to seek professional assistance from a museum curator or university instructor. There are several ways of doing this, but if you live near a museum or university you might telephone and ask for an appointment. If you live several miles away, it might be better to mail some of the material for examination. A customary practice is to allow the institution, if they so desire, to retain at least part of the material for their collections. It is well to remember also that such work is normally voluntary and that a large volume of unsorted materials may take more time than is available. In fact, two or three specimens at a time are about all that a busy specialist can afford to look at. If the material is of scientific interest or value, he may request additional amounts or even ask to visit the locality himself. Many of the really important discoveries have been located this way.

THE FORMATION OF COAL

Since a majority of the fossil plants in West Virginia are located in close proximity to coal beds, it is perhaps worth while to discuss the origin of coal.[3]

It is generally recognized that coal is formed from chemically and physically altered plant debris. Therefore, the first stage in coal formation is the growth and accumulation of plants. In our modern forests, leaves, stems, seeds and even an occasional tree litter the floor, but this material seldom accumulates in appreciable amounts because of decay. For example, if a tree is left lying on the ground, it is attacked at once by fungi, bacteria, insects, and other destructive organisms which, in time, reduce it to a rotten mass and ulimately to dust. Had the same tree been covered with stagnant water, the decaying processes would have been slowed or entirely halted. This, then, is the way that our coal beds were initiated

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[3] A more detailed discussion can be found in the West Virginia Geological and Economic Survey Educational Series publication, Coal and Coal Mining in West Virginia, by Oscar L. Haught. 1964.

—by the accumulation of plant debris in shallow depressions that were more or less constantly covered by water.

There are, of course, other factors that have to be considered. Under certain circumstances, decay may proceed as if on dry land or, if there is much current, the debris may be carried away nearly as quickly as it is deposited. Sometimes sand or mud is deposited with the plant fragments. This adulterates the accumulation and a carbonaceous sandstone or shale is the end result. But if the water is stagnant, and if very little sediment is washed into the depositional basin, then it is probable that plant debris will accumulate. This process occurs year after year, with new plants growing in and around the swamp constantly contributing to the deposit. As new layers are built up the additional weight gradually compresses the lower ones, air is slowly squeezed out and decay practically ceases. The resulting material, **peat**, is the initial stage in the formation of coal.

Later, as nearby hills and mountains are eroded away, quantities of sediments such as clay, sand, and gravel are washed into the basin and the peat deposits are buried. The area then begins to subside or settle as layer upon layer of material is added. After a while, the enormous weight of the overlying material compresses the peat even further and, as more of the gases and water are pressed out, **brown coal or lignite** is formed. As the deposit is buried even deeper, and consequently kept at higher pressure and somewhat higher temperatures, it loses more of its volatile matter and becomes **bituminous** coal. Under still greater pressure, caused by very deep burial or perhaps by movements of the earth's crust, **anthracite** coal is formed. During the same time, the overlying sediments are gradually changed into rock.

As millions of years pass, the earth continues to change. The downward movement is reversed and the rocks are elevated, sometimes into mountains. This movement must have been rather gentle because many of the coal beds and associated strata are horizontal or flat instead of being twisted or broken. Many thousands of acres of coal in what is now West Virginia have been carried away by downcutting streams as they helped form our mountains and river valleys.

The conditions for coal swamp formation are thought to have been a moderately warm to cool climate, abundant rainfall, and flat, poorly drained land. Essentially similar conditions on such a gigantic scale probably do not exist anywhere on the earth today.

How long did it take to form coal? Such a question can not be answered exactly, but geologists have estimated that it would take from eight to ten feet of good peat to make one foot of our common bituminous coal, and peat has been observed to be accumulating in modern swamps at the rate of approximately one foot per century. Although not an exact corollary, at this rate it would take 800 to 1,000 years for sufficient plant debris to accumulate to form one foot of bituminous coal. Therefore, the formation of sufficient peat to form a coal five feet thick would have required continuous peat swamp environment for approximately 5,000 years. Many additional thousands of years must have been required to complete the conversion process.

GEOLOGIC TIME

Man had no knowledge of the laws of nature when he first began to climb the intellectual ladder. Therefore, he tended to explain natural phenomena through supernatural happenings. With the passing of time he gradually became curious and sought other answers to explain what he observed. Perhaps among the first phenomena to attract his attention were the features of the landscape which surrounded him—the mountains and valleys, the streams and oceans. It is probable that he assumed that these features had always been and would always be. In fact, this concept of permanence is still with us and not infrequently we see references to the everlasting hills, although every high school student knows that even the highest mountains are not everlasting.

Another group of objects which attracted early attention were the fossil animals and plants. Many probably thought

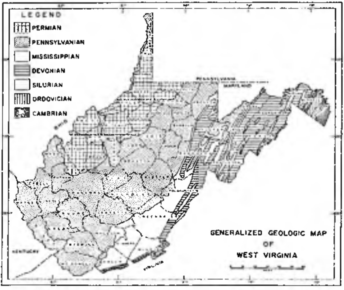

FIGURE 8.—Geologic map of West Virginia

them to be patterns which the creator had used in his work. Others were apparently satisfied to believe that they were the remains of life that had drowned during Noahs' flood. As the years passed man began to find factual answers, and we know today that these objects are the remains of animals and plants that lived in or near the places in which the evidences of their existence are now found. We also know that all aspects of our landscape contain numerous clues to their history—we just need to decipher them.

During prehistoric time, the face of West Virginia went through several drastic changes. In the very earliest days molten lava may have spilled over the area. High mountains, much higher than now, were uplifted and towered over the landscape until rain and frost and wind eroded them away. Time after time, great seas engulfed the land and then retreated. During all of this the earliest forms of life appeared—the fishes, amphibians, reptiles, birds, and mammals; the bacteria, algae, fungi, mosses, and large land plants—each leaving their remains preserved for all time in the rocks of their age.

Geologists (scientists who study the structure and composition of the earth's crust and how it was formed) have determined the order of formation or deposition of the various rock layers. They have also divided the rock column into major units, each with a distinctive assemblage of fossils. These units are called **systems.**

You will notice in Figure 9 that geologists recognize four **eras.** As we go back in time, we have the **Cenozoic, Mesozoic, Paleozoic,** and **Precambrian** in that order.

The **Cenozoic** is divided into two **periods—Tertiary** and **Quaternary.** The Tertiary, in turn, is subdivided into five **epochs,** which are, from oldest to youngest, the **Paleocene** ("ancient recent"), **Eocene** ("dawn recent"), **Oligocene** ("little recent"), **Miocene** ("less recent"), and **Pliocene** ("more recent"). A sixth epoch, the **Pleistocene** ("most recent") makes up the Quaternary. These epochs are named for the percentage of recent shells found in the rocks.

A different method was used in naming the Mesozoic **systems.** The oldest, **Triassic,** was named for its threefold nature in Germany; the middle, or **Jurassic,** for the Jura Mountains of France, which are largely formed from rocks of this age; and the **Cretaceous** after the Latin word **creta,** or chalk, which is descriptive of its most common rock type.

The **Paleozoic** rocks were named as follows: The **Cambrian** for Cambria, the old name for Wales; **Ordovician** and **Silurian** after Celtic tribes; **Devonian** for Devon, the place in England where the system was first recognized; **Mississippian** for the upper Mississippi River Valley; **Pennsylvanian** for the State in which it is so well developed; and the **Permian** after Perm on the Volga River in Russia.

ERA	PERIOD		AGE*	DOMINANT LIFE	
				PLANTS	ANIMALS
CENOZOIC	QUATERNARY	PLEISTOCENE EPOCH	1½ (2?)	HERBACEOUS PLANTS RISE, FORESTS AND GRASSES SPREAD	MAN APPEARS
	TERTIARY	PLIOCENE EPOCH	13		MODERN MAMMALS APPEAR AND DEVELOP
		MIOCENE EPOCH	25		
		OLIGOCENE EPOCH	36		
		EOCENE EPOCH	58		
		PALEOCENE EPOCH	63		
MESOZOIC	*CRETACEOUS*		135	ANGIOSPERMS RISE, GYMNOSPERMS DECLINE	DINOSAURS REACH PEAK, FIRST SNAKES APPEAR
	JURASSIC		180	CYCADS PHEVALENT	FIRST BIRDS AND MAMMALS APPEAR
	TRIASSIC		230	GYMNOSPERMS RISE, SEED FERNS DIE OUT, ANGIOSPERMS APPEAR?	REPTILES PROMINENT
PALEOZOIC	*PERMIAN*		280	CONIFERS & CYCADS IMPORTANT	REPTILES DOMINANT FIRST BEETLES AND LAND VERTEBRATES
	PENNSYLVANIAN		310	LEPIDODENDRON, SIGILLARIA AND CALAMITES DOMINANT	AGE OF COCKROACHES FIRST REPTILES
	MISSISSIPPIAN		345	LYCOPODS & SEED FERNS ABUNDANT	PEAK OF CRINOIDS AND BRYOZOANS
	DEVONIAN		405	FIRST SPREAD OF FORESTS	FIRST AMPHIBIANS INSECTS & SPIDERS
	SILURIAN		425	FIRST KNOWN LAND PLANTS?	FIRST AIR BREATHERS
	ORDOVICIAN		500	ALGAE, FUNGI BACTERIA	PEAK OF TRILOBITES, FIRST FISHES
	CAMBRIAN		600	ALGAE, FUNGI BACTERIA	TRILOBITES AND BRACHIOPODS
PRECAMBRIAN	*LATE*			ALGAE, FUNGI BACTERIA	NO PROVEN ONES
	EARLY		4500+	BACTERIA	NO FOSSILS FOUND

FIGURE 9.—Geologic time chart (*age in millions of years).

The **Precambrian** was so named because of its position below the lowermost **Cambrian** rocks. As our knowledge of this group of rocks has increased we have found that they are much thicker and must undoubtedly represent a greater length of time than all of the other systems combined.

West Virginia contains rocks that range from **Precambrian** to **Upper Pennsylvanian** in age.

For dozens of years, geologists have known that geological time is of immense duration, but it is only recently that they have developed methods of actually determining the age. This was made possible by the discovery of radioactivity. It is known that radioactive elements are unstable and that they undergo continuous disintegration until a stable end product is reached. One of the commonly used methods of dating is the **potassium-argon** technique which is thought to give a rather high degree of accuracy. It is based upon the fact that the disintegration of potassium-40 yields argon-40. Since the breakdown proceeds at a steady rate, a definite number of atoms are affected in each unit of time and the proportion of argon present in a given unit of potassium-40 is a measure of the time that has elapsed since the potassium was formed. Unfortunately, the potassium-argon method cannot be used for rocks less than one million years old.

Another method, called **Carbon-14** dating, is of great value to archeologists and to geologists interested in the last few thousand years, but the rapid rate of decay renders this method ineffective if the materials are more than about 35,000 years old. In summary then, the ages represented in Figure 9 are thought to be rather accurate, but a method to date sediments between about 35,000 and 1,000 000 years old would be of immense value.

SEQUENCE OF PLANT LIFE IN GEOLOGICAL TIME IN WEST VIRGINIA

The fossil record shows that plants have varied considerably in time of origin, rate of development, geologic range, etc. According to the theory of evolution, the earliest plants belong to the simpler groups while the later ones become progressively more complex.

Precambrian Eras

Satisfactory evidence is available to show that the earth had been in existence for a long time before the Cambrian Period. Therefore, rocks of Precambrian age must be present under later formed rocks. For this reason, we know that such rocks underlie the entire State, but they are deeply buried—with only a limited area outcropping at the surface near Harpers Ferry in Jefferson County.

Fossils of bacteria, algae and fungi have been found in Precambrian age rocks in Canada, but as yet they are not known to occur in West Virginia.

Paleozoic Era

West Virginia and Pennsylvania share the distinction of being the only states east of the Mississippi River to possess a complete unmetamorphosed geologic section from earliest Cambrian through uppermost Pennsylvanian.

CAMBRIAN

The Cambrian is the oldest group known to contain a great variety of fossils, and they are primarily animals. A considerable body of vegetation of some sort is implied, however, for the animals must have been, as they are now, either directly or indirectly dependent upon plants for their food.

During Cambrian times, the entire State was under the waters of a shallow sea in which sediment was being deposited. Consequently, Cambrian rocks underlie all of the younger beds, although the only exposures are a series of long narrow belts in Berkeley and Jefferson Counties, from which the overlying younger rocks have been eroded away.

In the course of their long history, a few members of several of the algal groups have developed the ability to secrete or to cause the deposition of calcium carbonate. Quite often no trace of plant structure is retained, but we can infer the algal origin from the general resemblance of the limestones to those being formed at the present time.

In the Conococheague Limestone, algal "structures" varying in size from small bodies a few inches in diameter to large ones several feet in diameter are common. The concentric laminae are accentuated during weathering. Headlike masses of this material are termed **Cryptozoons** (Plates 1 and 3).

ORDOVICIAN

During the greater part of Ordovician time, seas occupied all of the area that is now West Virginia and beds were deposited upon the Cambrian rocks. Exposures can be found in Jefferson, Berkeley, Hardy, Grant, and Pendleton Counties in the Eastern Panhandle, and Mercer and Monroe Counties in the southeast. Algal reefs are found at several horizons in the Beekmantown beds where the circular patterns are visible on weathered rocks.

In the latter part of the Ordovician the sea receded from the region, as is shown by the sediments which gradually changed from rather pure limestone, to shaly limestone, to calcareous shale and finally to sandstone. This total emergence resulted in erosion of the latest deposited Ordovician sediments.

SILURIAN

Silurian rocks are the oldest widely exposed Paleozoic beds in West Virginia. They were deposited in shallow seas upon the eroded surface of Ordovician rocks. During the Silurian, the sea fluctuated and withdrew, large beds of salt were deposited, the area was again submerged, and marine rocks were deposited over the salt.

Few algae are known at present from Silurian rocks in West Virginia, but a search of the included limestones should reveal algal colonies.

DEVONIAN

The Devonian began in West Virginia just as the Silurian ended, that is, covered by seas. Beds of this System underlie most of the State. They are exposed in many of the eastern counties, although in Jefferson County they have been removed by erosion. During late Devonian times, red sandstones and shales (Catskill Formation) were deposited both on land and in fresh water. It is in these rocks that the first unquestioned land floras occur in West Virginia. In addition, a microscopic study of some of the shales has revealed an abundant spore flora in many of the same zones. Further proof of a luxuriant vegetation is the appearance here and there of streaks of coal.

Among the most conspicuous plants are the fern-like leaves of **Archaeopteris** (Plate I, fig. 1) which were borne on gymnospermous-like trunks that often exceeded three feet in diameter and perhaps 60-70 feet in height. Another rather common fern-like plant is **Rhacophyton** (Plate 1, fig. 6), the remains of which have been found at several locations in the northeastern part of the State.

MISSISSIPPIAN

During this period, the area that is now West Virginia was alternately submerged and elevated above sea-level. The rocks are mainly a succession of shales, sandstones and limestones. The frequent intervals of emergence are indicated by numerous erosional surfaces and by beds of carbonaceous shale containing coaly streaks and fossils of land plants. Towards the middle of the period, the famous Greenbrier Limestones were deposited.

Beds of this age are exposed along the Appalachian Front and they underlie all of West Virginia to the west of this structure. They have been largely removed by erosion to the east of this line although localized areas are known.

Many species of spores originated from plants growing along the shores of the Mississippian seas and are preserved in the shales. Leaves and stems of land plants, such as **Triphyllopteris, Rhodea,** and **Lepidodendropsis** (Plate 31) also are found in these shales.

PENNSYLVANIAN

Deposition ceased at the close of the Mississippian and a long interval of erosion ensued. Throughout the Pennsylvanian, West Virginia was mostly a low, swampy plain covered with dense vegetation and subject to frequent, but short-lived, inundations.

The plants that flourished during this period have made West Virginia one of the best known fossil collecting sites in the world. Because of the good preservation, we know more about the Pennsylvanian vegetation in the State than any other except the present. The shales above the coals contain abundant spore floras. The leaf and spore floras changed throughout the period and, when studied successively, from the lower to the upper beds, are found to change in type and thus to reveal the vegetational development that took place.

Pennsylvanian rocks are present and exposed in all except Berkeley, Jefferson, Morgan, Hampshire, Hardy, and Monroe counties. They are practically the only exposed rocks west of the Allegheny Front, although a few valleys have been cut through to the underlying Mississippian beds.

PERMIAN

Some of the earlier geologists attributed the upper 1,200 feet of the stratigraphic column in West Virginia to the Permian System, but as new information became available the evidence for this decision was gradually refined. Today some geologists think that the entire sequence is Upper Pennsylvanian while others acknowledge that most of the rocks are Pennsylvanian, but that the uppermost ones are perhaps transitional between the Pennsylvanian and Permian ages. Typical Permian floras have not been found in West Virginia.

Mesozoic Era

There are no rocks of Mesozoic age in West Virginia. Those that were deposited, if any, have long since been removed by erosion.

Cenozoic Era

The statement for the Mesozoic Era will suffice for all of the Cenozoic except the Pleistocene. The glaciers of the ice age did not reach West Virginia but they did come close enough to block certain ancestral rivers that drained the State and thus created large lakes in which sediments were deposited. At least one such deposit, the Carmichaels Clay, which was formed in old Lake Monongahela in northern West Virginia and adjacent Pennsylvania about 1,000,000 years ago, contains extensive leaf, twig and pollen floras (Plates 37-40).

RECENT

Plants buried and preserved during the period since the last ice age are not usually considered as fossils. Nevertheless, some of these deposits contain interesting finds—particularly so because they are still represented in our modern flora and thus are easily identified. An example of this would be the leaves trapped in marl deposits (some of which are still being formed) in parts of eastern West Virginia.

THE CLASSIFICATION OF PLANTS

Everything that man attempts has a certain amount of classification involved, and paleobotany is no exception. Insofar as possible, fossil plants are classified according to a more or less natural system that is used for all plants, the basis of which is the nature and relationship of stem and leaf, the type and arrangement of the reproductive bodies, and the anatomy of the stem.

Since local names for plants vary widely, we follow the system developed many years ago by Carolus Linnaeus in which each plant is given two names—the first identifies the **genus**, and the second denotes the **species**. Both names are derived from Latin or Latinized Greek because it is a little-used language and, therefore, is not subject to great changes. It is universally agreed by the world's botanists that each name will be applied to just one plant.

In classifying plants, all of the obviously-alike individuals such as all of the sugar maple trees, make up the **species**. The second category groups together the species that are similar to one another, although differing to some degree among themselves, such as all of the maples. This unit is termed the **genus**. The obviously related genera are then brought together into a group called the **family**. In like manner, related families are grouped into **orders**, related orders into **classes**, and related classes into **phyla**. The phyla comprise the plant **kingdom**. Since these groups are more or less subjective units, none of them can be precisely defined.

Most systems of classification reflect current knowledge of the plant kingdom. Therefore, as new discoveries are made or as older knowledge is refined, the system changes. It is for this reason that a classification is not presented in this publication. Interested individuals should consult up-to-date botany textbooks for this information.

The assignment of a fossil plant to its proper niche often presents difficulties not encountered with modern plants. For example, fossil plants are usually preserved as fragments rather than as complete plants. In such instances, it is convenient to institute **form genera** for different portions of what later may prove to be a single plant. Whenever separate fragments named as form genera are found attached to other form genera—such as leaves to a stem—then the oldest published name has priority.

It is difficult for a beginner to make specific identifications. A trained paleobotanist can usually produce trustworthy results, but dozens of specimens are usually examined before any conclusions are drawn.

FOSSIL STEMS

Fossil plants are seldom preserved as entire units, but, in some instances, paleobotanists have been able to reconstruct complete plants from scattered fragments. The following four genera represent well-known reconstructions.

Calamites

(Fig. 10)

The genus **Calamites** includes large tree-like plants characterized by jointed stems, branches, and cones, and with leaves in whorls at the nodes. **Equisetum**, the well-known horsetail of our modern flora, it the only living genus with similar characteristics. Three subgenera are often separated according to the pattern of branching—**Stylocalamites**, with a few irregularly scattered branches; **Calamitina**, with branches in whorls at certain nodes; and **Eucalamites**, with branches at every node.

Calamites grew in thick stands on mud flats throughout Mississippian and Pensylvanian time. The fragmentary nature of the remains makes accurate size estimates difficult, but plants up to 30 feet in height were almost certainly present.

Pith casts of calamitean stems are common in the Mississippian and Pennsylvanian floras of West Virginia. The large pith cavity was filled with mud or sand as the plant was buried. Then, as the surrounding wood rotted or became coalified, the sediment hardened into a cast. Although occasionally preserved in their original cylindrical form (Plate 4, fig. 1) they were more often flattened as the weight of overlying sediments increased (Plate 4, fig. 2). The grooves on the cast represent woody strands which projected into the pith; the ridges represent rays. A small oval dot, the "infranodal canal" is normally recognizable just below the nodal line on the upper end of each ridge. Since the pith canal became smaller as the main stem was approached, the small tapered end of the cast represents the base (Plate 4, fig. 1).

Calamite leaves are assigned to **Annularia** (Plate 12, fig. 1-4) and **Asterophyllites** (Plate 12, figs. 5-7). The segmented, or noded, cones cannot be assigned to genera unless they are structurally preserved.

Cordaites

(Fig. 11)

Members of the genus **Cordaites** must have been rather common in Mississippian, Pennsylvanian, and Permian coal swamps. These trees probably attained heights of nearly 100 feet. The leathery strap-shaped leaves (Plate 18) ranged in size from a few inches to over three feet.

The stems contained a large pith characterized by closely spaced bands of tissue alternating with air spaces, much like the twigs of our present day walnuts. As a result, the pith casts are marked by closely spaced lines representing the edges of the tissue plates. They are assigned to the genus **Artisia** (Plate 18, figs. 5-6). Although most of the cordaitean

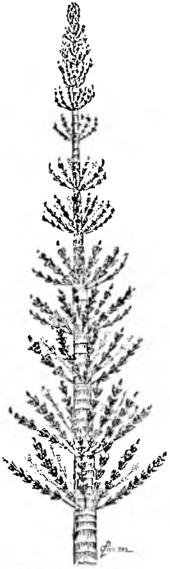

FIGURE 10.—Reconstruction of the top of **Calamites** (drawn by Paul W. Queen after Hirmer and others).

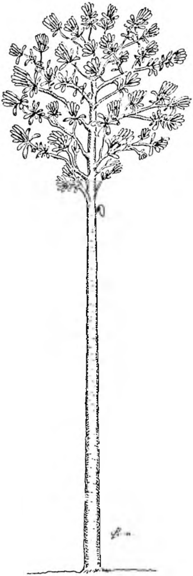

FIGURE 11.—Reconstruction of Cordaites (drawn by Paul W. Queen after Grand 'Eury).

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organs are known, the leaves and pith casts are the only ones commonly found in West Virginia.

Lepidodendron

(Fig. 12)

Lepidodendron was perhaps the most common tree-like plant of the Mississippian and Pennsylvanian periods. Typical representatives reached heights of up to 100 feet, with basal diameters of about three feet. Individual generic names have been applied to stems which have had various outer layers removed by decay, thus giving the appearance of belonging to different plants.

The linear or grass-like leaves, assigned to the genus **Lepidophylloides** when detached, vary from one-half inch to as much as 40 inches (Plate 20). An obvious distinguishing feature of the trunk and larger branches is the more or less diamond-shaped leaf-cushions. Near the center of each cushion is a scar that represents the point of attachment of the leaf (Plate 6).

The cones, borne at the tips of the smaller branches, are assigned to the genus **Lepidostrobus** (Plate 21, fig. 7). Different species vary in length from about one inch to over one foot, and the widths from less than one-half inch to over three inches. Individual cone scales are placed in the genus **Lepidostrobophyllum** (Plate 21, figs. 2-3).

In most cases, the underground root-like organs originated as four large "roots" (Plate 8, fig. 1) that forked several times as they spread through the mud. The casts of these organs, classified in the genus **Stigmaria** (Plate 7, fig. 1), are characterized by circular pit-like scars that mark the point of attachment of the rootlets. Quite often stumps of **Lepidodendron** occur in the roof shales of coal beds. Since they rest on top of the coal bed and taper upwards, they are deprived of support as the coal is removed and thus represent a danger to miners since they often fall without warning. Such stumps are commonly called "kettle-bottoms" (Plate 8, fig. 1). Specimens up to 53 inches in diameter and weighing several tons have been observed in West Virginia mines.

Lepidophloios, another arborescent lycopod, differs in several ways from **Lepidodendron**, but primarily in the leaf-cushions which are wider than high with the leaf-scar positioned near the lower margin.

Sigillaria was a related tree-like plant with some specimens being as much as six feet in diameter at the base. They differed from the above trees in that the leaf scars were arranged in vertical rows instead of in spirals and the trunks seldom branched. **Sigillaria** leaves are placed in the genus **Sigillariophyllum** when detached, but they are rarely distinguished from **Lepidophylloides**. As in **Lepidodendron** and **Lepidophloios**, different generic names have been given to

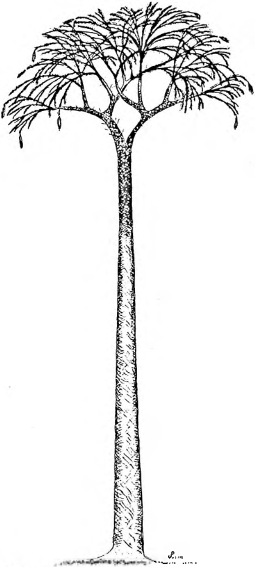

FIGURE 12.—Reconstruction of Lepidodendron (drawn by Paul W. Queen after various sources).

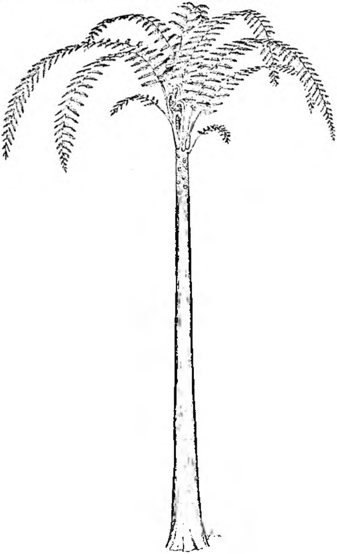

FIGURE 13.—Reconstruction of Psaronius (drawn by Paul W. Queen after Magdefrau and others).

stems that have had outer layers removed by decay before being preserved. One such genus is the commonly found **Syringodendron** (Plate 8, fig. 3).

Psaronius

(Figs. 13-14)

Psaronius is a genus of Paleozoic tree ferns that reached heights of perhaps 40 feet with diameters of at least three feet. Petrified trunks of this genus are supposedly rather common. A small stem was surrounded by a thick zone of adventitious roots that provided most of the support for the large crown of leaves. Although actual connection has yet to be demonstrated, the leaves associated with the trunk are of the pecopterid type (Plates 29-30).

FOSSIL LEAVES

The fossil leaves in West Virginia are of two general types—foliage of extinct Paleozoic plants, and Pleistocene representatives of our present day plants. Compressed specimens of the former are common in the shales above most coal beds and thus are better known to the average observer. In contrast, fossilized leaves of our modern trees are seldom

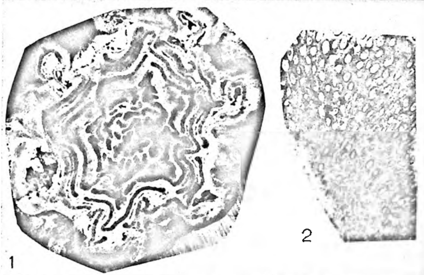

FIGURE 14.—Details of **Psaronius**. 1, Cross section of "center" showing vascular tissue; 2, Cross section of root zone that surrounds center. Both natural size.

noticed (p. 39). There are several reasons for this. For example, the average person is more familiar with hunting fossils around coal mines than he is in clay pits; the Paleozoic remains are in a resistant matrix and thus withstand weather-

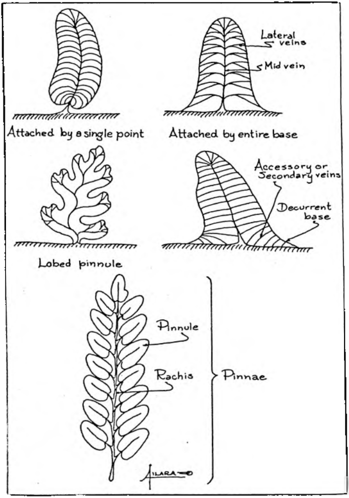

FIGURE 15.—Pictorial glossary showing key characteristics of fossil foliage.

ing for some time, while clay crumbles almost immediately; and coal deposits occur in two-thirds of West Virginia, whereas Pleistocene lake deposits are restricted to certain valleys.

The following key can be of value in determining the correct generic name for some of the common and representative form-genera of Carboniferous age. It should be obvious, however, that a key which does not contain all of the known genera is more of an exercise in working out characteristics than an absolute guide to proper identification. To proceed, select the more nearly correct number "1" entry, then move on to succeeding stages of the key as directed. Elimination of one set of characteristics at each stage will eventually lead to a name. The specimens can be compared with the description and illustrations for confirmation. Several of the characteristics used in the key are explained in Figure 15.

KEY TO COMMON TYPES OF PALEOZOIC FOLIAGE IN WEST VIRGINIA

1. Foliage arranged in whorls on jointed stems -------------- (2)
1. Foliage not in whorls on jointed stems ------------------ (4)
2. Leaflets with one simple vein; more or less lance-shaped to needlelike -------------------------------------- (3)
2. Leaflets with a repeatedly forking vein; wedge-shaped to broadly ovate. **Sphenophyllum** (Plate 13).
3. Whorl flattened in plane of stem, resembles a rosette. **Annularia** (Plate 12, figs. 1-4).
3. Whorl flattened laterally, leaflets cupped upwards around stem. **Asterophyllites** (Plate 12, figs. 5-7).
4. Specimen a large (usually several inches), irregularly lobed or highly dissected leaf-like structure—usually made up of complicated tufts and small vari-shaped tongues, veins indistinct. **Aphlebia** (Plate 11).
4. Not as above, actual leaf or pinnule ------------------ (5)
5. Long, slender, grasslike or strap-shaped leaves or pinnules (6)
5. Fern-like fronds or separate pinnules detached from them - (8)
6. Leaves long, grasslike, usually incomplete, with a single central vein normally represented by a groove. **Lepidophylloides** (Plate 20).
6. Leaves strap-shaped, with many veins ----------------- (7)
7. Leaves with numerous longitudinal veins, but without a distinct midvein. **Cordaites** (Plate 18, figs. 1-4).
7. Leaves with a well-developed midvein which gives off slender lateral veins. **Megalopteris** (Plate 22, figs. 1-2; Pl. 36, fig. 5).
8. Fronds with entire or smooth-margined pinnules, or occasionally lobed, toothed, or fringed, but not dissected - (9)
8. Fronds with distinctly lobed or dissected pinnules ---- (20)
9. Pinnules attached to rachis by a single point ------------ (10)
9. Pinnules attached to rachis by their entire base -------- (12)
10. Lateral veins form a network; pinnules tongue-shaped. **Linopteris** (Plate 23, fig. 5).
10. Lateral veins not forming a network ---------------- (11)
11. Pinnules tongue-shaped. **Neuropteris** (Plates 24 and 25; Pl. 26, figs. 4-5; Pl. 27, figs. 1-4, 6-7; Pl. 28, figs. 1 and 6-8).
11. Pinnules circular. **Cyclopteris** (Plate 26, figs. 1-3; Pl. 27, fig. 5).
12. Pinnules with more than one vein entering base ------ 13
12. Pinnules with a single vein entering base ---------- (18)
13. With accessory pinnae or pinnules between normal pinnae -- (14)

13. Without accessory pinnae or pinnules between normal pinnae -- (16)

   14. Pinnules scythe-shaped; intercalated pinnules half-round. **Lescuropteris** (Plate 23).

   14. Pinnules not scythe-shaped -------------------------- (15)

15. Pinnae nearly all the same size; pinnules with parallel margins perpendicular to the rachis and only slightly, if at all, decurrent. **Callipteridium** (not illustrated; see p. 32).

15. Pinnae diminished in size in descending order; pinnules decurrent and usually at an angle to the rachis. **Callipteris** (Plate 19).

   16. Midvein absent; several veins enter the base, fork and run longitudinally through the pinnule. **Odontopteris** (Plate 28, figs. 2-4).

   16. Midvein present; lateral veins arch from, or are nearly perpendicular to, midvein -------------------------- (17)

17. Lateral veins numerous to crowded, pinnules decurrent, often united at the base. **Alethopteris** (Plates 14 and 15; Pl. 16, fig. 3).

17. Lateral veins not crowded, base of pinnules usually constricted, not united, not decurrent. **Danaeites** (Plate 17, figs. 5-7).

   18. Pinnules decurrent -------------------------------- (19)

   18. Pinnules not decurrent. **Pecopteris** (Plates 29 and 30). (Poorly preserved **Danaeites** may key out here.)

19. Pinnules somewhat triangular, moderate to large; basal pinnule usually larger than the other. **Mariopteris** (Plate 33).

19. Pinnules small, laterally united; vein forks and veinlets angle sharply to 2 or 3 usually noticeable teeth. **Alloiopteris** (Plate 34, figs. 5-6).

   20. Pinnules dichotomously dissected into linear segments; the single vein in each segment bordered by a very narrow strip of laminae or leaf blade. **Rhodea** (Plate 31, figs. 3-5).

   20. Pinnules not dichotomously dissected into linear segments, lamina prominent ---------------------------------- (21)

21. Midvein seldom discernible and, if so, less than ⅓ the pinnule length -- (22)

21. Midvein discernible at least ⅓ the pinnule length -------- (23)

   22. Pinnules irregularly shaped and dissected, usually fragmentary. **Eremopteris** (Plate 34, figs. 1-4; Pl. 36, fig. 4).

   22. Pinnules rounded or divided into rounded segments. **Aneimites** (Plate 35, figs. 3-6). The large distinctly three-lobed form is usually assigned to **Triphyllopteris** (Plate 31, figs. 1-2).

23. Pinnules decurrent, leathery, somewhat triangular, basal pinnule on lower side of pinnae often larger and bi- or tri-lobed. **Mariopteris** (Plate 33). (Also see **Diplothmena** [Plate 35, figs. 1-2; Pl. 36, figs. 1-3]).

23. Pinnules stalked, or not distinctly coriacious; small. **Sphenopteris** (Plate 32) or **Diplothmena** (Plate 35, figs. 1-2; Pl. 36, figs. 1-3.

Alethopteris

(Plates 14 and 15)

The pinnules of **Alethopteris** are thick and leathery and are attached to the rachis by their entire, usually decurrent, and often confluent, bases. The prominent midvein continues to, or nearly to, the apex of the pinnule. It is represented as a ridge on the lower surface and as a deep groove on the upper side. Numerous lateral veins derive from the midvein and pass directly, with or without forking, to the margins. In addition, subsidiary or accessory veins pass directly from the rachis into the pinnule.

Alethopteris is a common genus throughout the Pennsylvanian rocks of West Virginia. The illustrations have been selected to show common species. Also see **Trigonocarpus** and **Dolerotheca,** Plates 16 and 17.

Alloiopteris

(Plate 34)

This form genus is used to classify fernlike fronds that are more or less intermediate between **Pecopteris** and **Sphenopteris.** It is characterized by small, alternately arranged, usually decurrent pinnules that are fused laterally. A single vein enters each pinnule, forks, and the resulting veinlets pass rather sharply to the margin where they terminate in two or three somewhat prominent teeth. An abnormal, deeply dissected leaf-like structure (**Aphlebia**) occurs typically at the base of each pinnae.

Although large specimens seem rare, sterile detached pinnae are not uncommon in the Pocahontas and New River coal fields of southern West Virginia. The thick nature of the leaf and the black matrix in which the specimens are normally found makes diagnostic photography rather difficult.

Annularia

(Plate 12)

Annularia is one type of calamite foliage. The leaflets radiate in whorls or rosettes from the nodes of slender twigs. They are somewhat lance-shaped, have convex margins, are often unequal in length, and contain a single central vein.

At least five species have been found in West Virginia. Also see page 21.

Aphlebia

(Plate 11)

These vari-sized leaf-like structures probably represent modified pinnules. They are usually deeply, but irregularly, lobed or lacerated. The bizarre appearance is furthered by an irregular veination or by wrinkles or folds which simulate veins. A common conjecture is that they were protective devices for young buds or shoots.

Archaeopteris

(Plate 1)

Archaeopteris is the leaf of certain aborescent or tree-like ferns of Devonian age. The large fronds are composed of a straight rachis on which are borne two rows of rather large, more or less wedge-shaped, pinnules. A single heavy vein enters the narrow base of each pinnule and divides extensively with the resulting branches passing to the margin.

This plant is sometimes found in extensive mats in Upper Devonian Catskill rocks. Individual fronds or pinnules suitable for photographing are rare.

Asterophyllites

(Plate 12)

Asterophyllites is a second type of calamite foliage. These leaves are similar to **Annularia** in that they are borne in whorls at the nodes of slender twigs, are united inconspicuously by a basal sheath, and have a single central vein. They differ by being more or less equal in length, by cupping upwards around the stem, and by having parallel leaf margins.

Three species have been recorded from the Pennsylvanian System in West Virginia. Also see page 21.

Callipteridium

(Not illustrated)

Callipteridium fragments are very similar to, and thus often confused with, certain species of **Alethopteris.** In general, the pinnules are only slightly, if at all, decurrent; the midvein carries only about two-thirds of the way to the apex, and the tip is usually obtuse.

The composition of this genus is interpreted differently by European and American paleobotanists. A key characteristic however, and one that must be present for positive identification, is the occurrence of small accessory pinnae on the rachis between the normal pinnae.

Under this interpretation, **Callipteridium** is thought to be a rare plant in West Virginia. Accurate identification is almost impossible with fragmentary specimens, but the uppermost plant-bearing horizons in the State apparently contain at least one species. This genus is included solely because of its similarity to **Callipteris.** It was probably a seed fern.

Callipteris

(Plate 19)

Callipteris is a variable genus with alethopterid-like pinnules. The main distinguishing feature is the presence of pinnules (intercalary) on the main rachis between normal pinnae. In addition, the obliquely attached pinnae decrease in size in descending order. It was probably a seed fern.

This genus is a much discussed plant because of its usefulness in many parts of the world as an index to Permian rocks. It has been reported from the younger coal-bearing sequences in West Virginia, but recent workers have been unsuccessful in collecting the genus as well as in agreeing on the taxonomy of existing collections. The illustration is an idealized sketch from the paper in which the first West Virginia specimens were described.

Cordaites

(Plate 18)

This form genus includes the compressed remains of long, slender, strap-shaped, stemless leaves. They contain numerous longitudinally aligned veins, but a midvein is not apparent. Complete leaves are often assigned to sub-genera according to their overall shape, but most of our specimens are too fragmentary or poorly preserved for accurate classification. Also see page 21.

Fragmentary remains of this early gymnosperm are common in West Virginia.

Danaeites

(Plate 17)

Sterile pinnules of **Danaeites** are easily confused with certain species of **Pecopteris.** In general, they are oblong, obtuse, or blunt, and usually, though not always in the more terminal pinnules, constricted at the base. The veination is often obscured in the thick pinnules, but the lateral veins arise from a well-developed midvein and arch to the margin, sometimes singly, but usually forking once just after leaving the midvein. In well preserved specimens, subsidiary or accessory veins are noticeable. The fertile pinnules bear the fructifications in linear series from the midrib to the margins.

Danaeites is a common fern in the upper one-third of the West Virginia coal measures.

Lepidophylloides

(Plate 20)

Fragments of these linear, more or less grass-like leaves of arborescent lycopods are common at nearly every fossil plant horizon in the Pennsylvanian of West Virginia. They vary in size from a fraction of an inch on the terminal twigs to perhaps as much as three or four feet on the larger limbs or trunks. Also see page 24.

Lescuropteris

(Plate 23)

Lescuropteris is characterized by broadly attached, scythe-shaped pinnules in which the lower veins emerge directly from the rachis and the upper ones cut off alternately from the thin "midvein". The rachis is "winged" by intercalated half-round leaflets between the pinnae bases.

This seed fern has been found several times in roof shales of the Pittsburgh coal. In some collections certain species of **Odontopteris** have been erroneously identified as **Lescuropteris.**

Megalopteris

(Plates 22 and 36)

Megalopteris is the name applied to strap-shaped pinnules with a well-developed midvein from which numerous fine lateral veins are given off perpendicularly or at a slightly ascending angle. The architecture of the frond is not well known, although one species was apparently palmate. Fragments of this plant are common in upper Pottsville rocks, but they are rarely well-preserved.

Neuropteris

(Plates 24-28)

The pinnules of **Neuropteris** are tongue-shaped with a thick, leathery appearance. They are typically attached to the rachis by a single point or by only a small part of the more or less heart-shaped base. Numerous lateral veins arch from an indistinct midvein and fork from one to several times in passing to the margin. The pinnae tip bears either one large terminal pinnule or two smaller ones according to the species. Lobed or dissected (polymorphic) pinnules are rather common in upper Pennsylvanian horizons.

Neuropteris is one of the more common seed ferns in Pennsylvanian sediments.

In some imparipinnate (having one terminal leaflet) species, circular leaflets with similar veination are attached along the rachis or at the base of the larger tongue-shaped pinnules in much the same fashion as stipules on present-day plants. These leaflets were originally described under the name **Cyclopteris** (Plates 26 & 27) before their attachment to **Neuropteris** was discovered. The name is still retained as a form-genus for isolated pinnules. Similar pinnules are known to occur on certain species of **Odontopteris** and **Linopteris**.

Linopteris

(Plate 28)

Linopteris is similar to **Neuropteris** except that the veins form a network. It is a common fossil in Allegheny and Conemaugh horizons.

Other Neuropterid-Linopterid Names

The late Walter Gothan, one of the world's great paleobotanists, devised and published a more natural classification for the Neuropterid group—one which, in time, will undoubtedly supersede the above commonly used, but more artificial system. He used the different types of frond architecture and different types of seeds to separate the family into four genera. More recent work with epidermal characteristics has been reported to indicate that even these genera may actually encompass several more natural genera, some of which are perhaps not closely related.

I. Neuropterids imparipinnate (one terminal leaflet)
   a. Regular veination—**Imparipteris**
   b. Veins in network—**Reticulopteris**

II. Neuropterids paripinnate (two terminal leaflets)
  - a. Regular veination—**Paripteris**
  - b. Veins in network—**Linopteris**

Odontopteris

(Plate 28)

This genus of seed ferns probably evolved from **Neuropteris** through a breaking up of the large pinnules into segments. It is characterized by smooth-margined pinnules that are attached by their entire base, and by the several veins which pass directly, or after forking one or more times, from the rachis to the margin. Care must be taken to exclude polymorphic forms of **Neuropteris** from this genus (note Plate 24, fig. 3).

Odontopteris is a common fossil in upper Pennsylvanian beds of West Virginia.

Pecopteris

(Plates 29 & 30)

Pecopteris is one of the largest, most interesting, and perhaps least understood, of all Paleozoic leaf-like form-genera. It serves as a provisional genus for sterile fronds of several affinities. Some members were seed ferns, some were true ferns, and others are as yet unassigned. As fertile specimens are found and described they are removed from **Pecopteris** and placed in a more natural genus.

The genus is characterized by relatively small pinnules with entire (usually), parallel, or slightly curved margins that are either free or laterally fused and which are attached to the rachis by their entire base. A single vein enters the base of each pinnule and extends to, or nearly to, the tip. Lateral veins arise from this midvein and pass either simple, forked, straight or curved to the margin. The main frond rachis often has dots, scales, striations, hairs, or other features that are useful in classification. Many of the species have been lumped into distinct sub-families.

Several dozens of different species have been reported for West Virginia, although recent work suggests that some of them only represent different stages of maturity or variations within different parts of the same plant. **Pecopteris** is uncommon in Pottsville age rocks, but is regularly found at all of the upper Pennsylvanian horizons.

Rhodea

(Plate 31)

The pinnules of **Rhodea** are dichotomized into linear segments. Each of the rather thin ultimate divisions contains a single vein bordered by a very narrow strip of lamina or leaf blade. **Rhodea** is a common fossil in the shales accompanying the Mississippian coals of the Eastern Panhandle.

Sphenophyllum

(Plate 13)

Sphenophyllum is a genus somewhat like **Calamites**, but much smaller. The interpretation of this plant varies quite widely; some consider it a small, shrubby plant, others are certain that it was vine-like, and still others think that it grew in water.

The leaflets are in whorls at the nodes. They are typically wedge-shaped with the narrow end being attached. The outer margin may be concave, convex, straight, deeply lobed or split, or with blunt or pointed teeth. One vein enters the base from which it dichotomizes throughout the blade. Roots were often produced at nodes along the stem and some of the branches terminated in segmented cones.

At least 6 species of **Sphenophyllum** have been found throughout the Pennsylvanian System in West Virginia.

SPHENOPTERIS, MARIOPTERIS, ANEIMITES, AND RELATED GENERA

These genera are presented together because marginal species often intergrade with one another. Although they are interpreted differently by different authors, the characteristics given below have been selected to establish what is sometimes considered as the "typical" form of each.

Sphenopteris

(Plate 32)

Sphenopteris is a large and diversified genus. The small, lobed or toothed, basally-contracted, oval to oblong pinnules are attached to the rachis by a short stalk. A single vein enters the pinnule and serves as a midvein although sometimes assuming a flexuous course. The primary lateral veins, usually one to a lobe, fork from one to several times as they pass to the margin.

Some species are known to be ferns, some are seed ferns, and others are of unknown affinity. The genus occurs throughout the Pennsylvanian column in West Virginia and is a dominant element in some of the lower beds.

Mariopteris

(Plate 33)

This genus contains fern-like fronds in which the primary, leafless or naked, axis splits equally into two divisions, with each fork dichotomizing again before giving off pinnae. The leathery pecopterid-like pinnules are attached by their entire base. They are sometimes joined laterally, are always decurrent, have entire, wavy, or lobed margins, and are often somewhat triangular. The lateral veins normally arise at an acute angle from the rather strong midvein and fork one or more times before reaching the margin. The basal pinnule on

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the lower side of each pinnae is often somewhat larger than the others and is sometimes prominently bi- or tri-lobed.

It is difficult to separate "marginal" species because the pinnules vary in size and form on different parts of the same frond.

Mariopteris is a common seed-fern throughout the Pennsylvanian System in West Virginia.

Eremopteris

(Plates 34 and 36)

Eremopteris resembles **Sphenopteris** in over-all appearance and has been included in that genus by some authors. The pinnules, however, are usually larger, more irregularly lobed or dissected, decurrent, and lack a definite midvein. Some species have prolonged spinose terminals, although normal and spinulose pinnules often occur on the same frond. In addition, the pinnule tips often appear abraded and/or broken.

This genus of seed-ferns is sometimes common in Pottsville horizons and has been observed throughout the lower two-thirds of the Pennsylvanian System in West Virginia.

Diplothmena

(Plates 35 and 36)

It is impossible to draw a sharp line of distinction between **Mariopteris, Diplothmena,** and even certain species of **Sphenopteris. Diplothmena** was established to include fern-like fronds in which the leafless axis forks just once before giving off pinnae, instead of twice as in **Mariopteris.** Later authors, however, have pointed out the intergradation of this characteristic. In general, the pinnules are not as leathery-appearing as in **Mariopteris,** they have a narrower point of attachment to the rachis, and are more or less evenly and deeply lobed as in **Sphenopteris.** The veination is much the same as in **Mariopteris.**

The above characteristics point out the difficulties inherent in attempting to delimit meaningful form-genera although, from a stratigraphic viewpoint, it is worthwhile to retain as many of them as is possible.

Diplothmena is found throughout much of the Pennsylvanian System in West Virginia.

Aneimites

(Plate 35)

The pinnae of **Aneimites** are rather delicate-appearing, although the individual pinnules are fairly large and sometimes leathery-appearing. The more or less ovate pinnules are often separated, to varying degrees, into two or three rounded segments. The dichotomously forking veins spread evenly throughout the pinnule.

The large three-lobed form, usually assigned to **Triphyllopteris**, is characteristic of the Pocono or lower Mississippian sediments in West Virginia. Typical **Aneimites** is rather common in lower Pottsville horizons.

FOSSIL SEEDS, CONES, AND OTHER DETACHED FRUCTIFICATIONS

Aulacotheca

(Plate 17)

Aulacotheca is a microsporangiate organ. It consists of one layer of elongate, tubular sporangia fused laterally so as to form a hollow cylinder. It is common in the lower Pennsylvanian rocks of West Virginia as a small striated compression that tapers to a point both at the base and at the apex. Intensive searching will probably turn it up at nearly all horizons.

Carpolithus

(Not Illustrated)

Carpolithus is the name assigned to smooth, rounded to egg-shaped compressions or casts that have the general overall appearance of a seed, but which do not have really definitive characteristics. It is a very common fossil in West Virginia.

Dolerotheca

(Plate 16)

Dolerotheca is a large, complex, microsporanginate organ. It consists of several dozen tubular, radially aligned sporangia held together in a bell-shaped (campanulate) structure. The compressed forms present quite different appearances according to the surface exposed. The paired rows of sporangia radiating from the center of the fructification with new double rows being intercalated towards the periphery seems to be the characteristic most used to identify the fossil. Although rarely reported as a compression, it is locally abundant at several places in Upper Pennsylvanian horizons—particularly above the Pittsburgh coal.

Holcospermum

(Plate 17)

Holcospermum is the compressed remains of a large seed with rather strongly developed ribs, apparently of the **Trigonocarpus** type, but in which the outer layers were partially destroyed before preservation. They are common in all but the lowest of the Pennsylvanian horizons.

Trigonocarpus

(Plates 16 and 17)

Trigonocarpus includes casts of radially symmetrical seeds characterized by three prominent longitudinal ribs.

These seed-fern seeds vary from about 1/4 inch to perhaps 4 inches in length, and up to 1½ inches in diameter. They are common throughout Pennsylvanian horizons.

Cones

(Plates 21 and 22)

Well preserved compressions of fossil cones are seldom found and fragments are hard to identify with any degree of accuracy. In general, the proper assignment of a cone depends upon the degree of structural preservation. For this reason, the casual collector should perhaps label his materials as having calamitean affinities if the whorled, noded construction is evident, and as lycopodiacious if made up of spirally arranged bracts. A paleobotanist will usually offer additional help and guidance.

Fossil cones vary greatly in size and complexity of structure. Cones of less than an inch in length have been found, as have a few of more than 20 inches.

SPORES AND POLLEN

Palynology—the study of recent or fossil spores and pollen—is associated with the development of the microscope. Although these minute bodies have been observed for several hundred years, it is only recently that they have been intensively studied. Palynology is applied in the fields of pollen allergy and plant taxonomy, but the main interest lies in the successful use of these materials as aids in the identification of specific geologic horizons.

Plant microfossils have been found to some extent in nearly every type and age of sedimentary rock. They often have distinctive characteristics and are usually sufficiently different in each period so as to be of value in determining the relative age of the enveloping rocks. A few of the more common genera present in the coals and shales of West Virginia are illustrated to round out the story of plant fossils in this State (Plates 41, 42 and 43).

The methods of collecting, processing, and studying microfossils are varied and depend upon the type of rock involved, as well as on other factors. Interested individuals can locate sources of this information by writing to their State Geological Survey or University Geology Department.

FOSSIL REPRESENTATIVES OF MODERN FLORAS

(Plates 37-40)

Fossil records of our modern floras are meager, but enough is known to show that they extend back many thousands of years. The records consist of plant fragments, such as leaves, seeds, and wood, and of microfossils, such as pollen, spores, and diatoms (see page 19).

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The best known assemblage in the State, collected from ancient Lake Monongahela clays within the city limits of Morgantown, emphasizes the similarity of the floras of the last million years. Specimens of oak, beech, birch, pine, sweet gum, and elm dominate the leaf flora. Microfossil preparations contain these genera as well as a few others that have not yet been found as megafossils.

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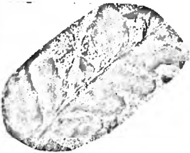
PLATES

All Illustrations Are Natural Size

Unless Otherwise Indicated.

PLATE 1. Archaeopteris, Pseudofossil, Algal Limestone, Tree Cast, and Rhacophyton.

1. **Archaeopteris** pinnules from Preston County.
1a. Sketch of **Archaeopteris** pinnule.
2. Artifact, pseudofossil or dendrite. Caused by the redeposition of weathered manganese-bearing rock by circulating water.
3. Algal limestone.
4. Polished surface of one type of algal limestone to show the banded nature.
5. Cast of 8-inch diameter tree in sandstone cliff. Such casts are typically several feet long.
6. **Rhacophyton** from Randolph County. Large masses of sporangia and smaller twigs are common in some localities.



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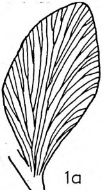

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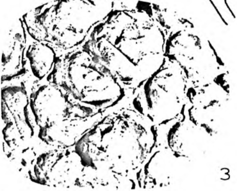

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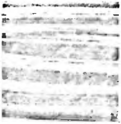

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PLATE 2. Pseudofossil.

Large flattened concretion in Chemung sandstone northeast of Valley Head, Randolph County. These structures were once thought to represent fossil trees. The length of the rule is one foot. (From Vol. XV, W. Va. Geol. Surv.)

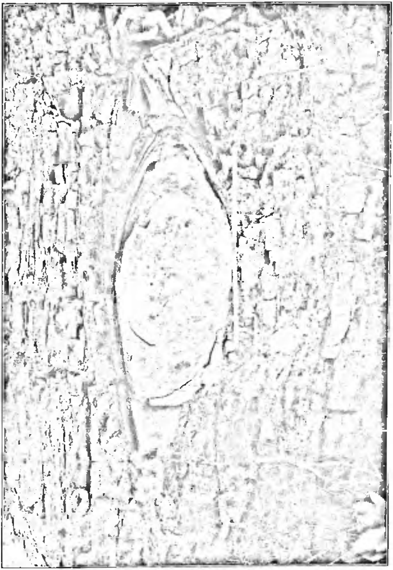
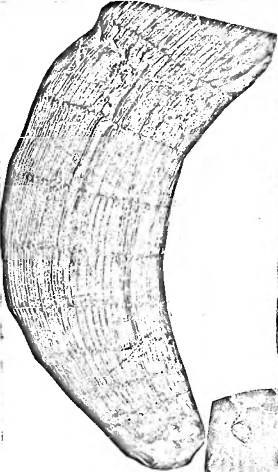


PLATE 3. Cryptozoon

Cryptozoon algal structure in Conococheague Limestone near Spring Mills, Berkeley County. (From Vol. XX, W. Va. Geol. Surv.)

PLATE 4. Calamites.

1-3. **Calamites** pith casts. Note the infranodal canals just below the node in Figure 1, the flattened compressed nature in Figure 2, and the branch scars in Figure 3.



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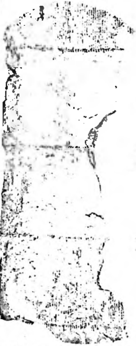

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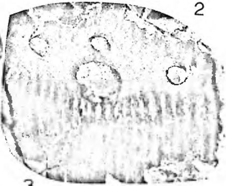

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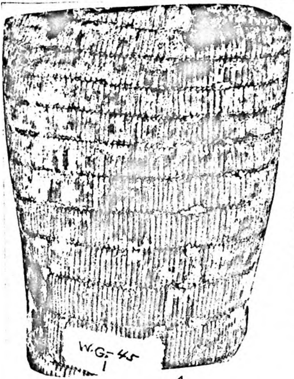
PLATE 5. Calamites.

1-3. **Calamites** pith casts. Note the alteration of the ribs from node to node and the infranodal canals near the top of each rib.



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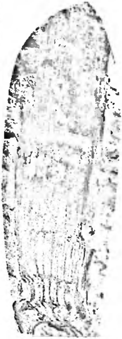

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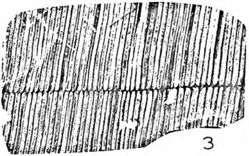

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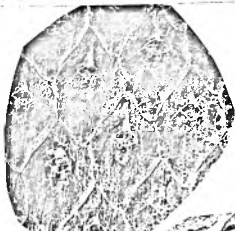
PLATE 6. Lepidodendron.

1-6. **Lepidodendron** bark patterns. Note the spiral arrangement of the "cushions" and the smaller, angular leaf scars near the center of each.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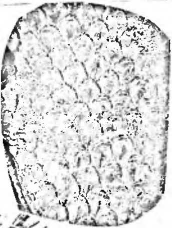
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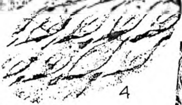
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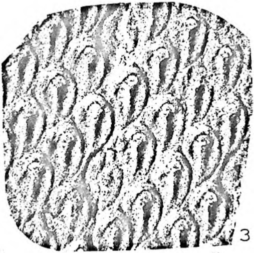
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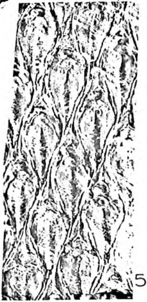
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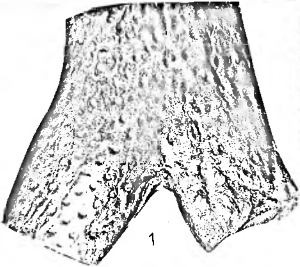
PLATE 7. Stigmaria and Calamites

1. **Stigmaria.** Note the equal or dichotomous forking. (X 1/2.)

1a. Enlargement of surface pattern to show the circular depressions from which the lateral "rootlets" arise (X 1-1/2.)

2. **Calamites** pith cast. This specimen is a stem that collapsed during burial.



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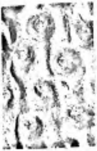

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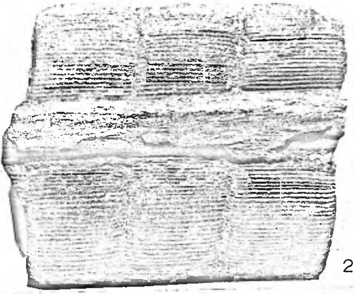

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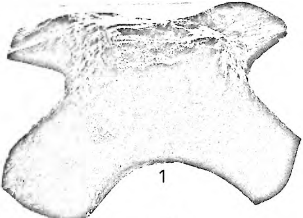
PLATE 8. Lepidodendron, Syringodendron, and Sigillaria.

1. Base of **Lepidodendron**. Note the four primary stigmarian axes that radiate from just below the soil line. (X 1/8.)
2. Compressed stem of seed-fern.
3. **Syringodendron**. The large (parichnos) scars have been enhanced by erosion or decortication of the stem.
4. **Sigillaria.**



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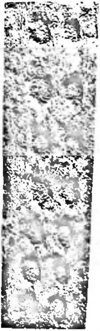

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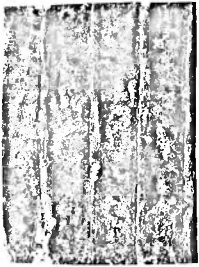
PLATE 9. Sigillaria.

1-5. **Sigillaria.** Note the vertical arrangement of the leaf scars. Figure 1 was extensively decorticated before preservation, but the parichnos scars that typify **Syringodendron** are not present.



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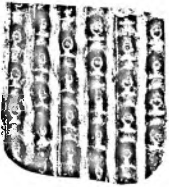

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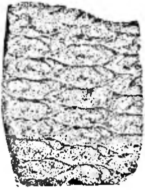

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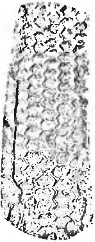

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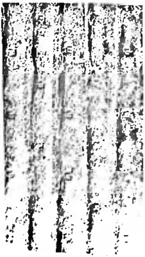

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PLATE 10. Sigillaria.

1. Large sandstone cast of **Sigillaria** in Logan County, W. Va. This tree remained standing as the sediments piled up around it. The cast is about 9 feet high.

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1

PLATE 11. Aphlebia.

1-2. **Aphlebia.** Note the lack of symmetry of form and veination.

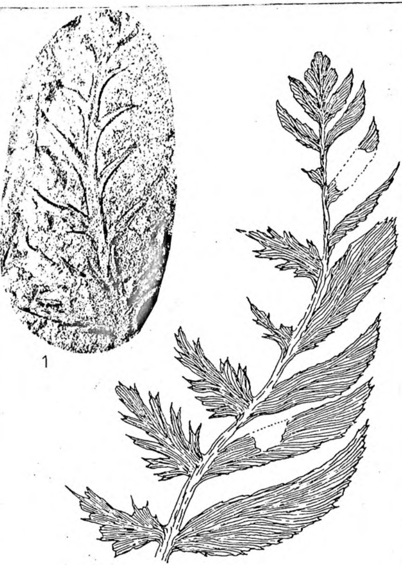

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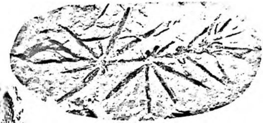
PLATE 12. Annularia and Asterophyllites

1-4a. **Annularia.** Each of the four figures represents a different species. Figure 4a shows the rather heavy nature of the single vein.
5-7. **Asterophyllites.**
8 Cone of the **Asterophyllites** shown in Figure 7. (X 3.)

1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4a

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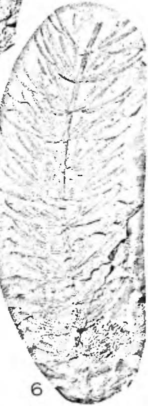
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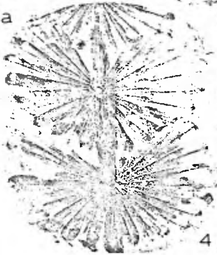
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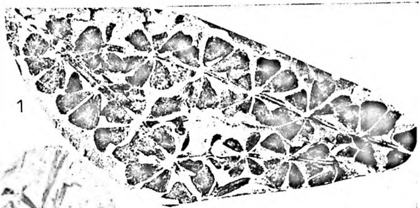
PLATE 13. Sphenophyllum.

1-6. Sphenophyllum. The darkened pinnule in Figure 6 has been painted with clear fingernail polish.



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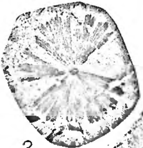

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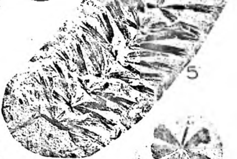

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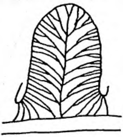
PLATE 14. Alethopteris.

1-5. **Alethopteris.** The sketch in Figure 1 shows the veination of a common species. Figures 3 and 5 are from different parts of the same specimen. Figures 2 and 4 are of the same species.



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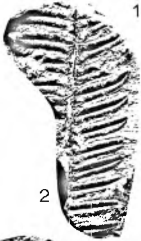

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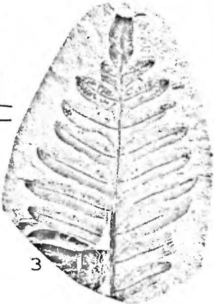

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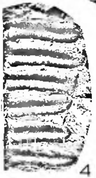

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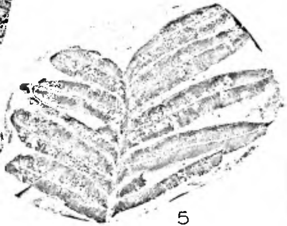

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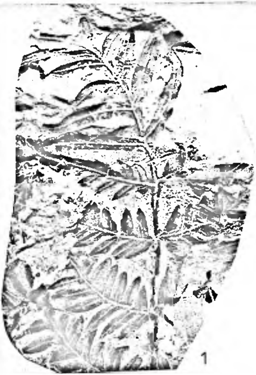
PLATE 15. Alethopteris

1-4a. **Alethopteris.** Note the different sized pinnules near the tip of Figure 1. Figure 4a is an enlarged sketch of a pinnule from Figure 4.



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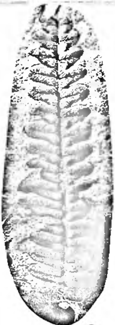

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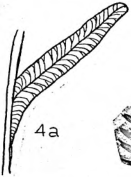

4a

3

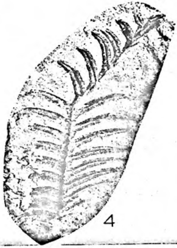

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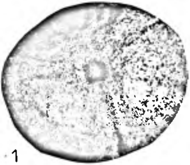
PLATE 16. Trigonocarpus, Alethopteris, and Dolerotheca

1-2. **Trigonocarpus** casts. Note point of attachment.
3. **Alethopteris.**
3a. Enlargement of Figure 3 to show veination. (X 3.)
4-5. **Dolerotheca.** Note the pores in the bottom of this pollen-bearing organ.



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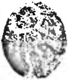

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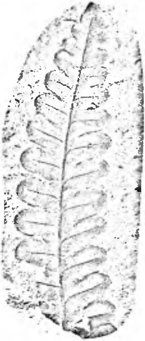

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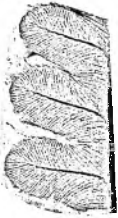

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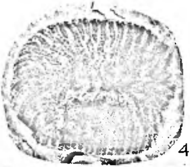

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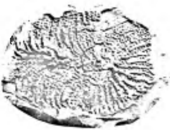

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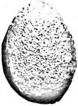
PLATE 17. Trigonocarpus, Aulacotheca, Holcospermum, and Danaeites.

1-2. **Trigonocarpus casts.**
3. **Aulacotheca.** (X 3.)
4. **Holcospermum.**
5-7. **Danaeites.** Figure 5 shows both fertile and sterile foliage. Figure 6 illustrates the fertile condition and Figure 7 shows sterile pinnules.



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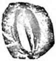

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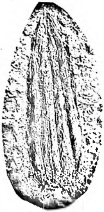

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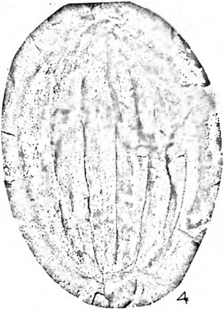

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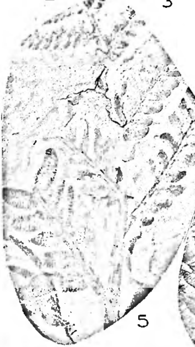

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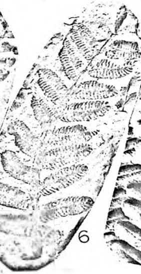

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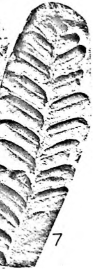

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PLATE 18. Cordaites and Artisia.

1-2. **Cordaites.** Complete leaves are seldom found.
3-4. Sketches showing different forms of **Cordaites** leaves. Reduced.
5-6. **Artisia.**

1

2

3

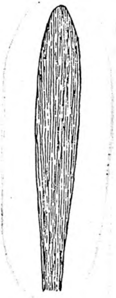

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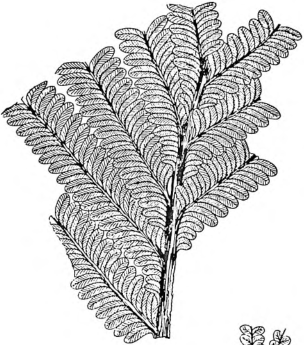
PLATE 19. **Callipteris.**

1-2. Sketches of **Callipteris** from the 1880 publication by Fontaine and White. Figure 1a represents an enlarged pinnule from Figure 1.



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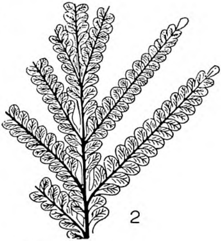

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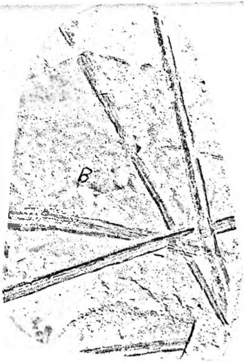
PLATE 20. Lepidodendron and Lepidophylloides

1. **Lepidophylloides.**
2-3. **Lepidodendron** twigs. The leaves are small **Lepidophylloides.**



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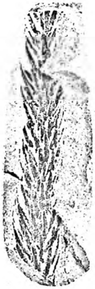

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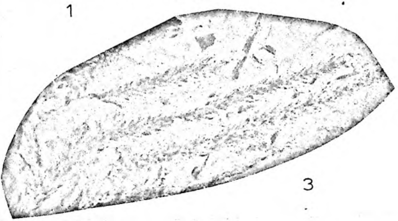

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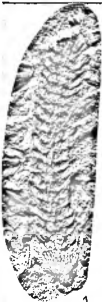
PLATE 21. Cones.

1. Calamite cone.
2-3. **Lepidostrobophyllum.**
4. Cross section of a **Lepidostrobus** cone.
5. Cone showing large sporangia or spore-bearing sacs above each bract.
6. Calamite cones.
7. **Lepidostrobus.**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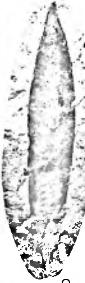
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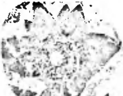
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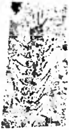
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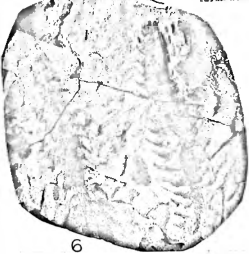
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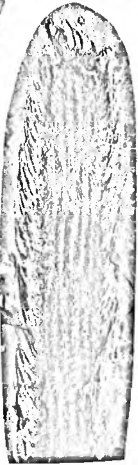
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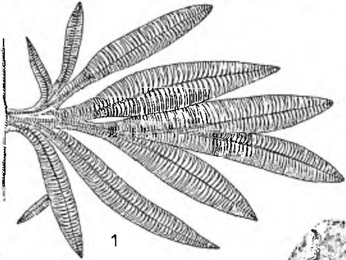
PLATE 22. Megalopteris and Calamite Cones.

1. Sketch of **Megalopteris** (after Lesquereux). See photograph of a similar specimen on **Plate 36, fig. 5.**
2. Sketch of **Megalopteris** tips. Fragments such as these are the typical finds.

3-4. Calamite cones. Note the whorled arrangement of the bracts.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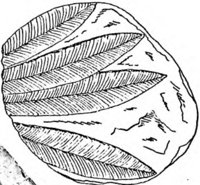
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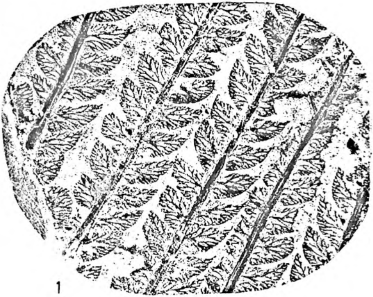
PLATE 23. Lescuropteris.

1. **Lescuropteris.**
2. Sketch of intercalary pinnule. (X 3.)
3. Sketch of regular pinnule. (X 3.)



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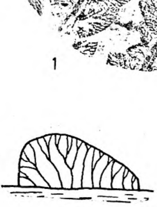

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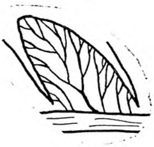

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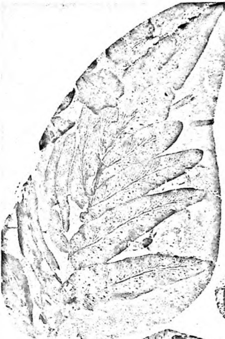
PLATE 24. Neuropteris.

1-4. **Neuropteris.** The punctations in Figure 1 were caused by pyrite "bumps". Figures 3 and 4 represent polymorphic forms of the species shown in Figure 2. Note the resemblance in Figure 3 to Odontopteris.



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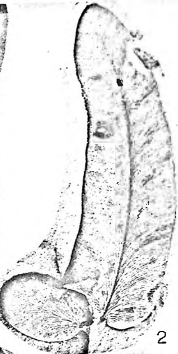

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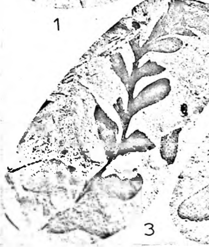

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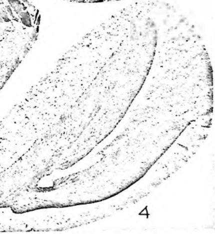

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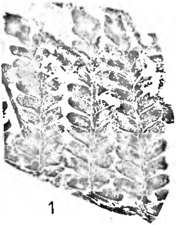
PLATE 25. Neuropteris.

1-6. **Neuropteris.** Figures 2, 3 and 4 represent different forms of **Neuropteris pocahontas.**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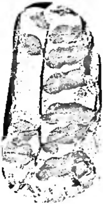
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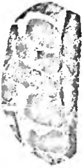
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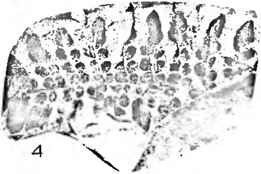
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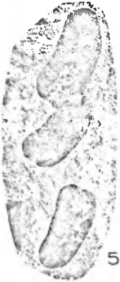
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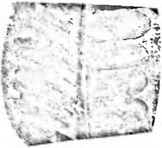
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PLATE 26. Neuropteris and Cyclopteris.

1-3. **Cyclopteris.** Note the polymorphic form in Figure 2.
4. **Neuropteris,** with basal cyclopterid pinnules.
5. Pinnule of **Neuropteris** showing polymorphic form.

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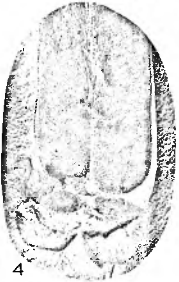
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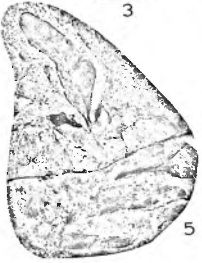
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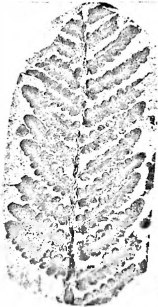
PLATE 27. Neuropteris and Cyclopteris.

1 and 7. **Neuropteris.** Both specimens are the same species, but Figure 1 shows older pinnules.
2-3. **Neuropteris.** Note the different sized pinnules near the tip of Figure 3.
4. Fragment of a polymorphic **Neuropteris** pinnule.
5. **Cyclopteris.** This fringed form is associated with **Neuropteris ovata**, shown in Figure 2.
6. Polymorphic neuropterid pinnule.



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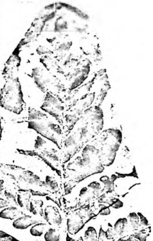

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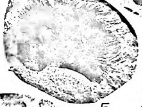

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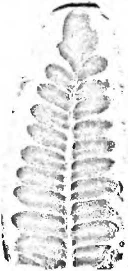

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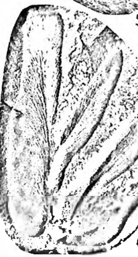

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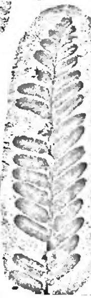

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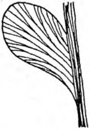
PLATE 28. Neuropteris, Odontopteris, and Linopteris

1. **Neuropteris** rachis.
2. **Odontopteris.**
3-4. Sketches of **Odontopteris** pinnules.
5. **Linopteris.**
5a. Enlargement of Figure 5 to show the nature of the veination.
6-7. **Neuropteris** pinnules (fragments) with hairs showing that delicate structures are often preserved.
8. **Neuropteris.**



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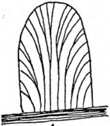

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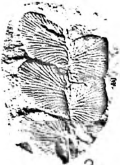

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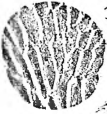

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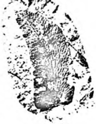

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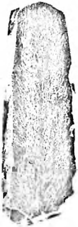

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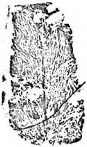

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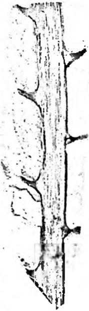

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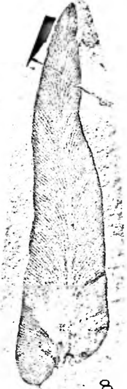

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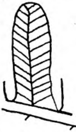
PLATE 29. Pecopteris.

1- 6. Sketches of **Pecopteris** pinnules to show common veination patterns.
7-10. **Pecopteris.** Note the sporangia on Figure 9.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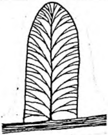
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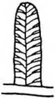
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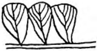
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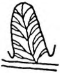
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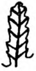
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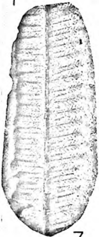
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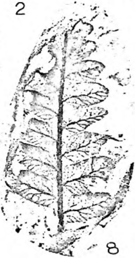
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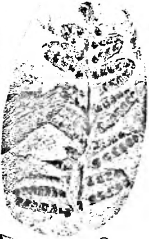
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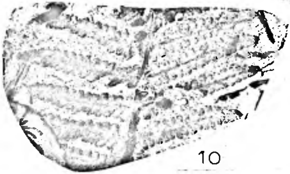
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PLATE 30. Pecopteris.

1-6. **Pecopteris.** Figure 4a is an enlargement of Figure 5 to illustrate the veination. Note the progressive lobing from tip to base in Figure 2. The edges of the pinnules in Figure 1 are rolled under.

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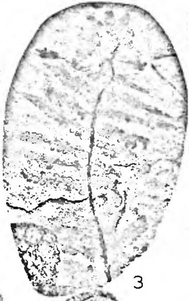

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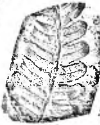

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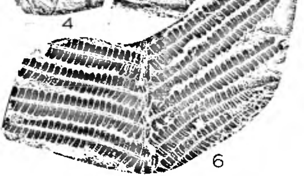

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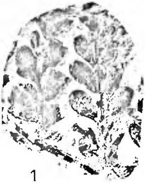
PLATE 31. Triphyllopteris, Rhodea, Lepidodendropsis, and Archaeocalamites.

1-2. **Triphyllopteris.**
3-5. **Rhodea.**
6. **Lepidodendropsis.** This represents an early form of **Lepidodendron.**
7. An early plant resembling a calamite from the **Devonian** of West Virginia. Identified by David White as **Archaeocalamites** which is separated from **Calamites** by nonalternating ribs.



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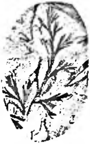

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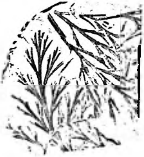

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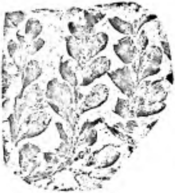

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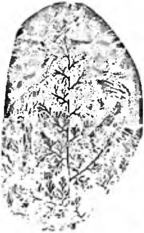

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PLATE 32. Sphenopteris.

1. Sphenopteris.
2. Sphenopteris stem.

3-5. Sphenopteris. Figure 5 represents a sketch of a portion of Figure 4.

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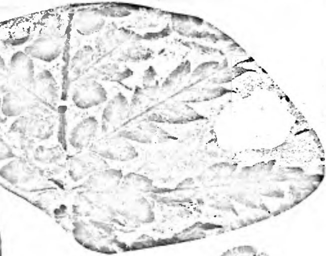
PLATE 33. Mariopteris.

1-4. Mariopteris.



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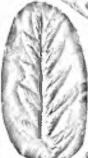

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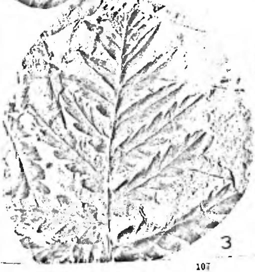

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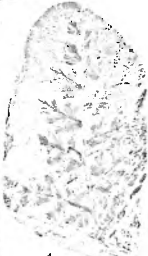

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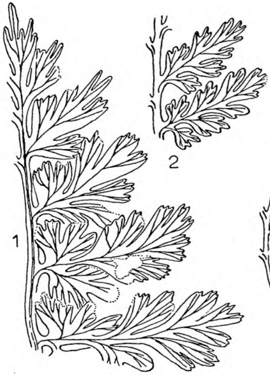
PLATE 34. Eremopteris and Alloiopteris

1-4. Sketches of **Eremopteris** (after David White).
5. Sketch of **Alloiopteris** to show pinnule form.
6. Enlarged sketch of **Alloiopteris** to show veination.



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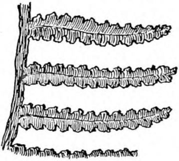

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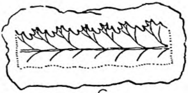

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PLATE 35. Diplothmena and Aneimites.

1. Sketch of Diplothmena to illustrate form.
2. Enlarged sketch of Diplothmena to show veination.
3-6. Enlarged sketches of Aneimites to show form and veination.

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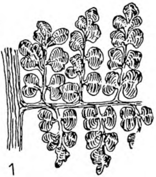

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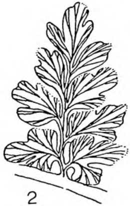

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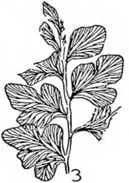

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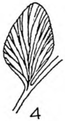

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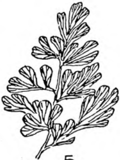

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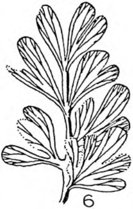

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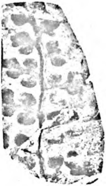
PLATE 36. Diplothmena, Eremopteris, and Megalopteris.

1-3. **Diplothmena.**
4. **Eremopteris.**
5. **Megalopteris.** Note sketch of a similar specimen in Figure 1 on Plate 22.



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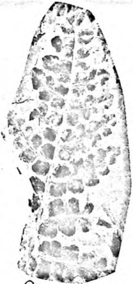

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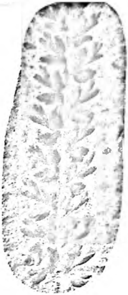

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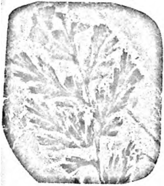

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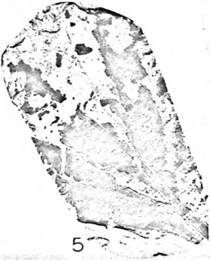

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PLATE 37. White Pine, Beech, and Sweet Gum.

1. White pine (**Pinus strobus**) needles.
2. Basal half of a white pine cone.
3. Husk from a beechnut.
4. Leaf of American beech (**Fagus grandifolia**).
5. Sweet gum (**Liquidambar styraciflua**) "fruiting" body.
6. Sweet gum leaf.

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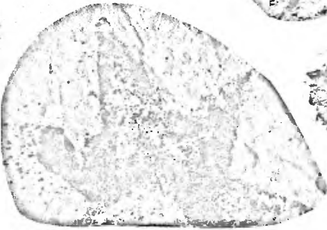

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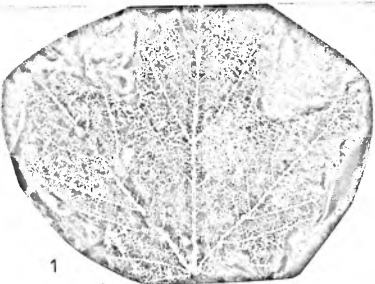
PLATE 38. Sugar Maple and Sycamore.

1. Sugar maple (**Acer saccharum**) leaf. In this specimen, the organic material has been replaced by **vivianite**, a powdery bluish-colored mineral.
2. Sycamore (**Platanus occidentalis**) leaf.



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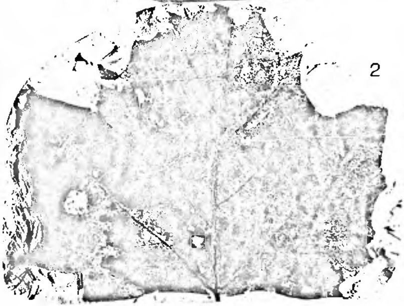

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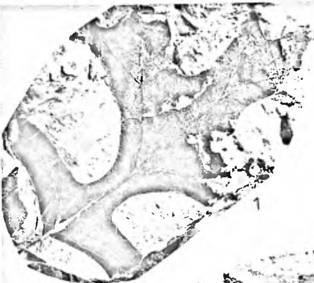
PLATE 39. Oak.

1. Scarlet (?) oak **(Quercus coccinea)** leaf. (The leaves of scarlet oak are virtually indistinguishable from those of pin oak, **Q. palustris.)**
2. White oak **(Quercus alba)** acorn. (X 1-1/2.)
3. White oak leaf.
4. Red oak**(Quercus rubra)** leaf. (This leaf could just as easily be assigned to black oak.)



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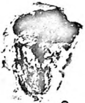

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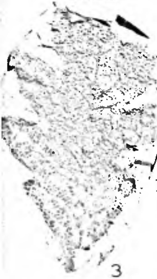

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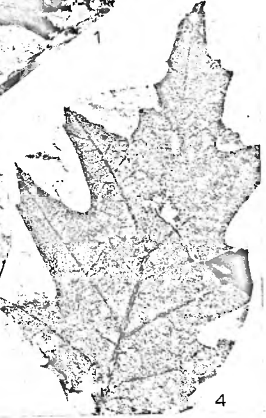

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PLATE 40. Modern Pollen Commonly Found in Bog and Lake Deposits in West Virginia.

All magnified about 500 times; actual sizes are given in microns (a micron is one-thousandth of a millimeter). Note the variations in pores and furrows and in the size and shape of the different grains. Note also the wings or bladders on pine and spruce.

1. American chestnut (**Castanea dentata**). 17 microns.
2. Red pine (**Pinus resinosa**). 90 microns.
3. Red spruce (**Picea rubens**). 107 microns.
4. Basswood (**Tilia americana**). 42.5 microns.
5. Sycamore (**Platanus occidentalis**). 22.5 microns.
6. Willow (**Salix discolor**). 25 microns.
7. Shagbark hickory (**Carya ovata**). 50 microns.
8. Brookside alder (**Alnus serrulata**). 22.5 microns.
9. Cattail (**Typha latifolia**). Tetrad 42.5 microns overall.
10. Yellow birch (**Betula lutea**). 37.5 microns.
11. Sugar maple (**Acer saccharum**). 35.5 microns.
12. Buckeye (**Aesculus octandra**). 28 microns.

13-14. Red oak (**Quercus rubra**). 32.5 and 37.5 microns.

15. Eastern hemlock (**Tsuga canadensis**). 77.5 microns.
16. Large cranberry (**Vaccinium macrocarpon**). Tetrad 42.5 microns overall.
17. Beech (**Fagus grandifolia**). 45.5 microns.
18. Grass (**Gramineae**). 31 microns.

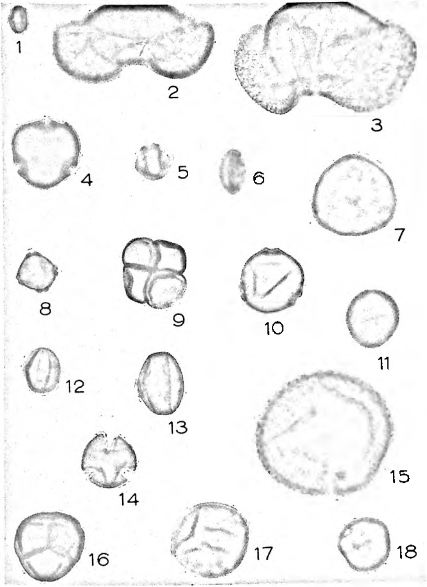
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PLATE 41. Fossil Plant Spores.

Transmitted light photomicrographs of some representative small spore genera of the Pennsylvanian System. (All magnified 750 times.)

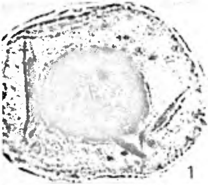
1. **Endosporites** sp. spore body, 40 microns. Overall diameter, including bladder, 84 microns. Known affinities: Lycopodiales, Lepidodendraceae.

2-3. **Raistrickia** spp.
Figure 2, spore body 53 microns; individual spines up to 13 microns.
Figure 3, spore body 68 microns; blunt projections vary from 2-8 microns in length.
Affinity: Filicales.

4-5. **Lycospora** spp. 33 and 29 microns respectively. Known affinity: Arborescent Lycopods.

6. **Reticulatisporites** sp. Maximum diameter 108 microns. Affinity: Known in fructifications allied with **Sphenophyllum.**

7-9. **Granulatisporites** spp. 40, 21 and 48 microns respectively. Affinity: Filicales (?).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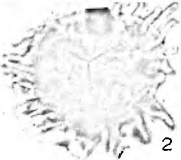
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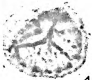
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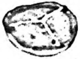
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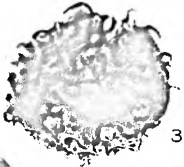
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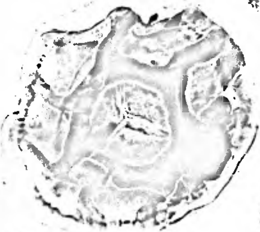
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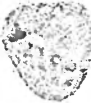
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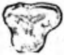
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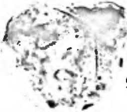
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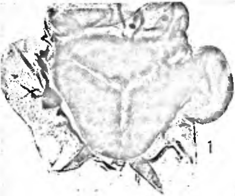
PLATE 42. Fossil Plant Spores.

Transmitted light photomicrographs of some representative small spore genera of the Pennsylvanian System. (All magnified 750 times.)

1. **Alatisporites** sp. Diameter exclusive of bladders, 53 microns. Overall diameter, about 92 microns.
   Affinity: Cordaitales (?).
2. **Granulatisporites (Leiotriletes)** sp. 35 microns. Known affinities: Bryopsida, Filicales.
3. **Calamospora** sp. 93 microns. Affinity: Sphenopsida.
4. **Punctatisporites (Microreticulatisporites)** sp. 87.5 microns.
   Affinity: Sphenopsida (?).
5. **Florinites** sp. 82.5 microns. Affinity: Cordaitales.

6-7. **Laevigatosporites** spp. 57.5 and 40 microns respectively. Known affinities: Equisetales, Sigillariaceae.

8. **Thymospora** sp. 32.5 microns. Affinity: Filicales (?).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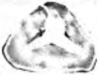
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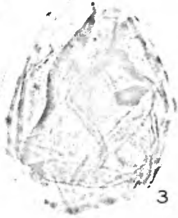
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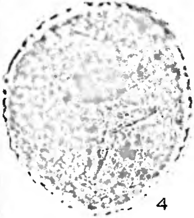
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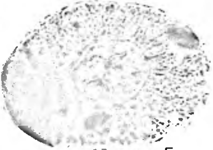
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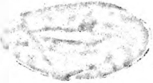
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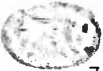
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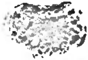
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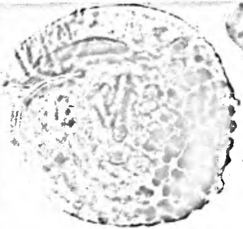
PLATE 43. Fossil Plant Spores.

Transmitted light photomicrographs of some representative small spore genera of the Pennsylvanian System. (All magnified 750 times.)

1. **Schopfites** sp. Maximum diameter, 98 microns.
   Affinity: Unknown.
2. **Reinchospora** sp. 48 microns.
   Affinity: Possibly Filicinean.

3-4. **Triquitrites** spp. 50 and 30 microns.
   Affinity: Filicinean.

5. **Granulatisporites (Acanthotriletes)** sp. 38 microns.
   Affinity: Unknown.
6. **Punctatisporites** sp. 76 microns. Known affinities: Psilopsida, Filicales, Pteridospermae.
7. **Densosporites** sp. 43 microns.
   Affinity: Lycopsida.
8. **Wilsonites** sp. 88 microns overall.
   Affinity: Sigillariaceae(?).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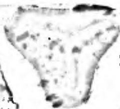
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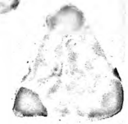
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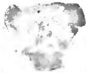
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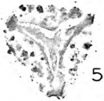
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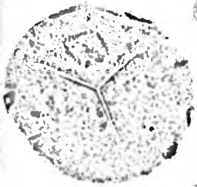
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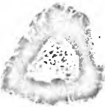
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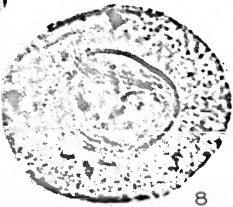
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LIBRARY
POTOMAC STATE COLLEGE
KEYSER, W. VA.

560.9754 20243
G41 Gillespie, BC 18614
W.Va. Plant fossils of W.Va.

Potomac State College
Keyser, W. Va.

1. All pupils in the school are entitled to use the library and to draw books.

2. Reference books, such as encyclopaedias and dictionaries, are to be used only in the library.

3. Reserved books may be borrowed for one period, or at the close of school, and should be returned before the first class the following school day.

4. All other books may be retained for two weeks.

5. Two cents a day is charged for each book kept overtime.

6. Injury to books beyond reasonable wear and all losses shall be paid for.

7. No books may be taken from the library without being charged.